Prepared for:
Puerto Rico Electric Power Authority
Central Aguirre, PR

Prepared by:
AECOM
Chelmsford MA
60212039
February 2013

Thermal Plume Mapping Study of Outfall 001 at the Aguirre Power Plant Complex

Prepared for:
Puerto Rico Electric Power Authority
Central Aguirre, PR

Prepared by:
AECOM
Chelmsford MA
60212039
February 2013

Thermal Plume Mapping Study of Outfall 001 at the Aguirre Power Plant Complex

Stephanie GK Wilson

Prepared By Stephanie Wilson

Donald W. Kretchmer

Revised By Donald Kretchmer

Aaron Hopkins

Final Draft Reviewed By Aaron Hopkins

Contents

List of Appendices

List of Tables

List of Figures

1.0 Introduction

1.1 Site Description

The Aguirre Power Plant Complex (APPC) is located on the south coast of Puerto Rico within the municipality of Salinas, on the northwest shoreline of Bahia de Jobos (Jobos Bay) (Figure 1-1). Jobos Bay is formed by Punta Pozuelo, protruding from the east, and a series of islands (cays) on the south (Cayos Caribes) and southwesterly sides (Cayos de Barca). Water depths range from 2 to 20 feet throughout most of the bay with deeper depths of 28 to 34 feet in the western bay (Figure 1-2). The dredged ship channel is maintained at 27 feet.

The APPC consists of two 20 megawatt (MW) oil-distillate-fired gas turbine generator power packs, two 300 MW combined-cycle distillate-fired units, and two oil-fired 450 MW steam-electric units. The APPC employs a once-through cooling system utilizing ocean water withdrawn via an intake structure located along the northwest shoreline of Jobos Bay. A total of four (4) circulating water pumps (plus one spare) convey a total of 452,500 gallons per minute (gpm), or approximately 226,250 gpm per generating unit. Heated cooling water flows from the steam-electric units into an open discharge channel. At the end of the discharge channel, seven pumps, (six operating; one spare) each with a design capacity of 106.6 million gallons per day (MGD), convey water to Outfall 001 at a maximum rate of 639.6 MGD (444,167 gpm). The discharge pumps convey the cooling water into a 4,800 foot long, 13 foot inside diameter, circular pipe that runs along the seafloor. The discharge port at the end of the pipe is a 10-foot restrictor that discharges into Jobos Bay, east of Punta Colchones (Figure 1-1). The discharge velocity at the port is calculated to be approximately 12 feet per second (fps) at full load.

1.2 Regulatory Status

There are presently no nationally applicable standards for thermal discharges from steam electric power plants. The United States Environmental Protection Agency (U.S. EPA) has the authority to establish those standards on a case-by-case basis taking into account the factors enumerated in Section 306 of the Clean Water Act (CWA). Further, Section 316(a) of the CWA provides the permit applicant the opportunity to demonstrate that their proposed effluent controls are appropriate "to assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife". Current Puerto Rico Water Quality Standard (PRWQS) (Section 1303.1 (D)), states that “except by natural causes, no heat may be added to the waters of Puerto Rico, which would cause the temperature of any site to exceed 90°F (32.2°C)” and that “no thermal discharge or combination of thermal discharges into or onto the surface, estuarine and coastal waters shall be injurious to aquatic life or the culture or propagation of a balanced indigenous population there of nor in anyway affect the designated uses” (EQB 2010).

The APPC discharge was designed to comply with the thermal standards promulgated by the Environmental Quality Board (EQB) in 1974 to minimize the impact that the discharge may have on the Jobos Bay environment. Under the thermal standards promulgated by EQB in 1974, Section 2.1.5 states that “no heat may be added to the waters of Puerto Rico which would case the arithmetic mean of the maximum daily temperature at any site prior to the addition of heat, to be exceeded by more than 0.833°C (1.5°F).” In addition, Article 5 states that "the size and shape of the mixing zones shall be determined individually by the Board according to the location, size, nature and classification of the receiving waters. In no case the mixing zone will be larger than 4,000 feet in diameter". The discharge temperature at the outfall is dependent on the inflow temperature and the condenser temperature rise (CTR). The theoretical maximum discharge temperature based on the maximum CTR and a maximum ambient water intake temperature of 88.7°F (31.5°C) is 106°F (41.1°C). PREPA monitors the discharge temperature from the Aguirre Power Plant 001 Outfall daily at the end of the discharge pipe. The plant discharges heated cooling water from Outfall 001 at temperatures that sometimes exceed the PRWQS for temperature. As a result, PREPA requested under Section 316(a) of the CWA an alternate thermal effluent limitation for the APPC Outfall 001. PREPA, in coordination with U.S. EPA, developed a study to determine the impact of the power plant on the ecosystem of Jobos Bay. As part of this study, a thermal plume model was developed to show the effects of operating the Aguirre Power Plant at full load, under the worst observed ambient conditions – September 2003. The average ambient temperature during the time period of simulation was computed to be 86.75 ºF and a large portion of the surface as well as bottom water temperatures exceeded 90ºF in the vicinity of the discharge (Washington Group 2005). The model results also indicated that the maximum temperature rise exceeding 3ºC was confined to very small area and volume of water near the surface. Conservatively, the 3ºC isotherm represented 0.26 percent of the surface area of Jobos Bay inside of the Cayos and 0.11 percent of the modeled bay volume. The maximum temperature rise was 4.61ºC for the simulation time period, in the center of the plume surface expression (Washington Group 2005).

This study formed the basis of a request for alternate thermal effluent limitations and the results were documented in a 316 Demonstration Report (Washington Group 2005). The results of the 316 Demonstration indicated that the thermal limitations under Puerto Rico water quality regulations were more stringent than necessary to protect the balanced, indigenous population of shellfish, fish and wildlife in and on the receiving waterbody. As a result of the findings of the 316 Demonstration, U.S. EPA issued PREPA a NPDES permit for APPC, effective January 1, 2011, with a defined daily maximum discharge temperature limitation at Outfall 001 of 106°F (41.1°C). The permit also defines a daily maximum temperature limitation of 90°F (32.2°C) at the edge of the Interim Mixing Zone (IMZ), pursuant to the Puerto Rico Water Quality Standards Regulation (EQB 2010).

The establishment of an IMZ is authorized under PRWQS Section 1305 and is valid for a "period not to exceed one and a half years; or until the NPDES permit expires; or a date which the Board determines….whichever comes first" (EQB 2010). Condition 23(m) of the current NPDES permit requires the implementation of a one year monitoring program to obtain the necessary data to validate the IMZ. The IMZ, as defined in the permit, is approximately 960 m long and 460 m wide, covering an area of 440,000 m^2. The condition states that the monitoring program shall consist of temperature monitoring at the boundaries of the IMZ and at the Outfall 001 to verify compliance with the applicable provisions of the NPDES permit limits and two dye studies to validate the mathematical model (Washington Group 2005) used to determine the critical initial dilution and verify the behavior of the plume within the mixing zone.

According to PRWQS Section 1305.9 (EQB 2010), final authorization of a mixing zone requires calibration and validation of the mathematical models used to define the IMZ. Validation of the mathematical model requires the following:

- Implementation of a one year monitoring program to validate the mathematical model during two seasons (winter and summer) and;

- Comparative analysis between the measured values in the sampling program and the values calculated by the model for corresponding points throughout the periphery of the mixing zone.

The model in which 90 percent of the calculated values are equal or less than the ones obtained through the sampling program shall be validated.

1.3 Study Objectives

The objectives of the study, as stated in Condition 23 of the NPDES permit and presented in the QAPP, were to perform a study to validate the mathematical model used to establish the IMZ and verify the behavior of the discharge within the mixing zone during two seasons (winter and summer). Although Condition 23 of the 2010 NPDES permit calls for the performance of a dye study, PREPA alternatively proposed to conduct a thermal plume mapping study in order to validate the mathematical model and verify the behavior of the plume within the mixing zone, according to Section 1305.9 of the PRWQS (EQB 2010). While both a dye study and a thermal plume study can produce the required data to validate the mathematical thermal model, according to PRWQS Section 1305.9, the thermal plume study would collect temperature data that are directly comparable to the results of the mathematical thermal model. In addition, specific tide, ambient temperature, and discharge conditions can be targeted by the thermal plume study to mimic the modeled scenarios.

A Quality Assurance Project Plan (QAPP) was prepared to present the organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with the requested dye dilution studies, as well as an alternative thermal plume mapping study, to validate the interim mixing zone of Outfall 001 at APPC (Appendix B). Specific protocols for field activities, equipment calibration and maintenance, and data analyses, including Standard Operating Procedures (SOPs), were described in the QAPP. All QA/QC procedures were structured in accordance with applicable technical standards and with the United States Environmental Protection Agency's (U.S. EPA) requirements, regulations, guidance, and technical standards, as presented in U.S. EPA Requirements for Quality Assurance Project Plans (U.S. EPA 2001) and U.S. EPA Region 2 Guidance for the Development of Quality Assurance Project Plan for Environmental Monitoring Projects (April 2004). Upon review of the QAPP, EQB conditionally approved the thermal plume study option in their September 9, 2011 letter (Appendix C).

The thermal plume study methodology is described in Section 2.0 and results of the data collection program are presented in Section 3.0 and summarized in Section 4.0.

Figure 1-1. Site Map

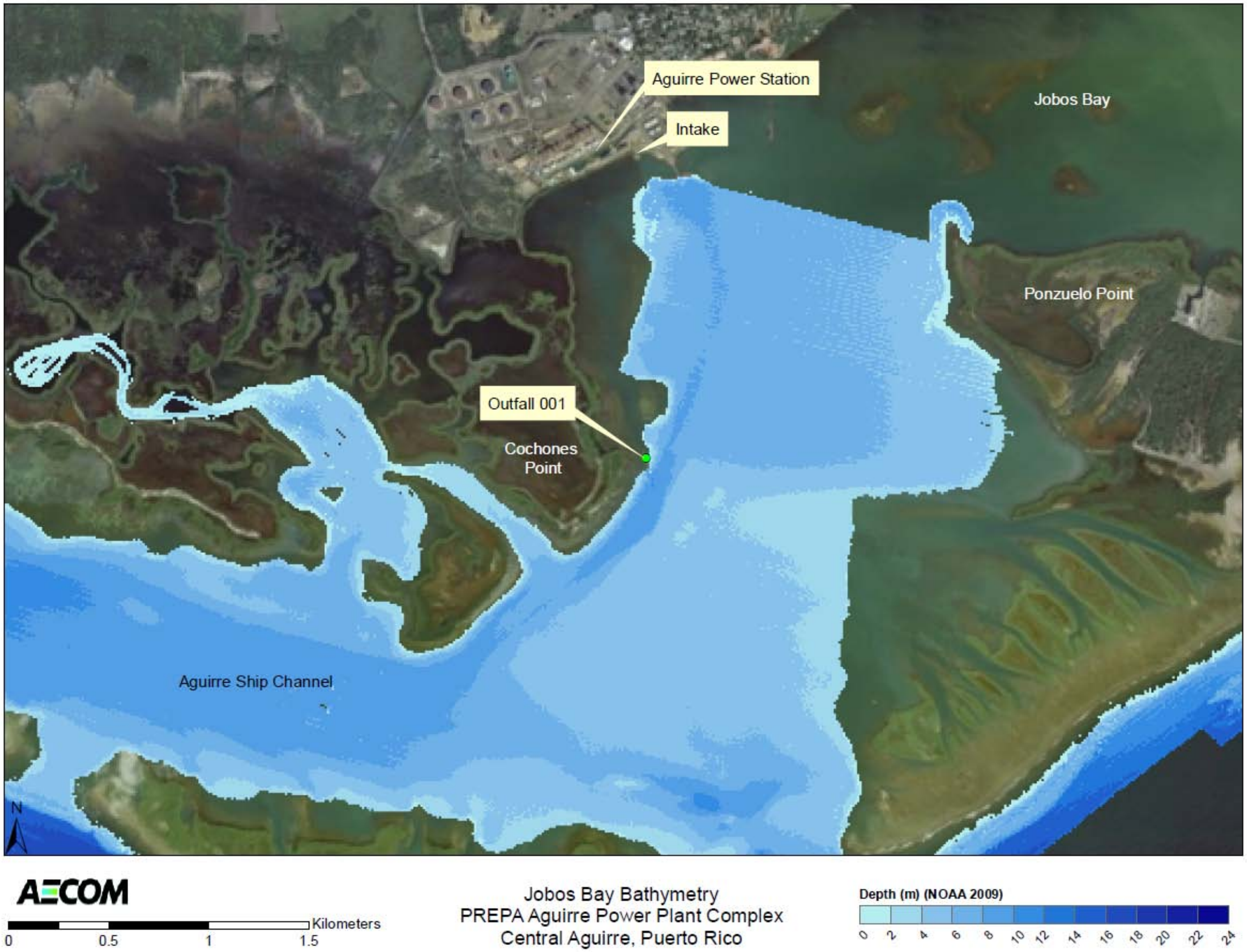


Figure 1-2. Bathymetry of Jobos Bay

2.0 Methods

The thermal plume characterization study was designed to characterize the thermal plume from the APPC Outfall 001 discharge through both deployed temperature moorings and real-time boat-based transect surveys. In accordance with the conditions of the NPDES permit and as stated in the QAPP, the thermal plume study was conducted twice over the course of a year in coordination with the temperature monitoring study, with one event occurring during the winter (March 2012) and one event during the summer (August 2012) (Table 2-1).

The study consisted of two major components. The first component involved the deployment of five in-situ temperature moorings to document water temperatures at the surface, mid depth, and bottom near the mouth of the discharge in Jobos Bay. In addition, a temperature sensor was placed at the head of the plant's discharge within the power plant. The second component was to conduct four thermal plume mappings of the discharge over a twenty-four hour tidal cycle, coinciding approximately with high slack, maximum ebb, low slack, and maximum flood tidal conditions. Due to Puerto Rico's location in the northeastern Caribbean, tides are of low amplitude (on the order of 1 meter or less) and semidiurnal, with unequal timing between the two lows and two highs per day.

Table 2-1. Summary of Data Collection Program

Methods	No. of Sampling Events/ 24 Hour Period	No. of Stations/Sampling Event	Depth (ft)
Temperature moorings	Continuous (5 min intervals)	5 moorings (1 at discharge and 4 in a "T" formation at 500-foot spacing	1 ft below surface Mid depth 1 ft above bottom
Thermal plume mapping	4 (high slack, maximum ebb, low slack and maximum flood tides)	Multiple transects	1 ft below surface and vertical profiles

Note: Both methods were conducted during each survey event.

2.1 Navigation and Sample Positioning

All fieldwork was conducted aboard a small center-console vessel provided by PREPA. The vessel was equipped with a DMS 212 differential global positioning system (DGPS) for navigation and positioning. The DGPS was interfaced with the PC-based hydrographic software package HYPACK for data acquisition and processing. The incoming data were logged on disk and processed in real time allowing the vessel position to be displayed on a video monitor and compared to pre-plotted tracklines and positions as the survey progressed. All positioning data were referenced to the Puerto Rico State Plane-North America Datum 1983 (NAD83), in feet.

Further details regarding the survey equipment and methodology are available in Appendix A.

2.2 Temperature Moorings

In-situ temperature moorings were deployed 13-15 March 2012 and 7-9 August 2012, for a period of 36 to 48 hours, to encompass the real-time thermal mappings surveys. A total of five temperature moorings were deployed near the mouth of the discharge in Jobos Bay. One mooring was placed directly in front of the discharge while the remaining four moorings were placed in a “T” formation at approximately 500 foot spacing (Figure 2-1). The instruments were set to record at 5-minute intervals.

Each mooring consisted of three Onset Hobo Water Temperature Pro v2 data loggers positioned at one foot below the surface, mid depth, and one foot above the bottom. In addition, one temperature sensor was deployed at the head of the plant’s discharge within the power plant to collect water temperature prior to passing through the discharge pipe. All temperature loggers were cross-calibrated in a temperature bath prior to deployment to maximize instrument accuracy. A linear calibration curve was used to post-process the data, resulting in temperature data with an accuracy of 0.1°F.

2.3 Thermal Plume Mappings

Real-time thermal plume mappings were completed four times on 15 March 2012 and 8 August 2012, covering a 24-hour tidal cycle (Table 2-2). The mappings also coincided with certain periods of the day, early morning, mid-day, late afternoon/evening, and midnight. This scheduling allowed for a complete survey of the discharge under a variety of daily conditions. The horizontal temperature data were acquired using a thermal monitoring system interfaced to a DGPS navigational software system aboard the survey vessel. The thermal monitoring system consisted of a central processing unit with YSI Model 44036 Series epoxy encapsulated thermistor probes. The probes were located on the side of the survey vessel, directly under the DGPS antenna, at a depth of one foot below the surface of the water. Transects were focused to an area within 3,000 feet of the discharge and a minimum of 10 lines were completed over each tidal cycle (Figure 2-2). Vertical profiles were also collected at selected sites along the approximate centerline of the plume, using an YSI 6920 conductivity/temperature/depth (CTD) vertical profiler (Figure 2-2).

Table 2-2. Thermal Plume Mapping Times

Sampling Events	Mapping Number	Mapping Period (AST)	Approximate Tidal State
Survey 1: 14 March 2012	1	05:00-07:14	High slack
	2	11:00-12:57	Max ebb
	3	17:00-19:08	Low slack
	4	23:00-01:06	Max flood
Survey 2: 8 August 2012	1	05:25-7:26	Low slack
	2	10:26-12:46	Max Flood
	3	15:36-17:53	High slack
	4	22:45-01:13	High slack/Ebb

AST – Atlantic Standard Time

Figure 2-1. Temperature mooring locations

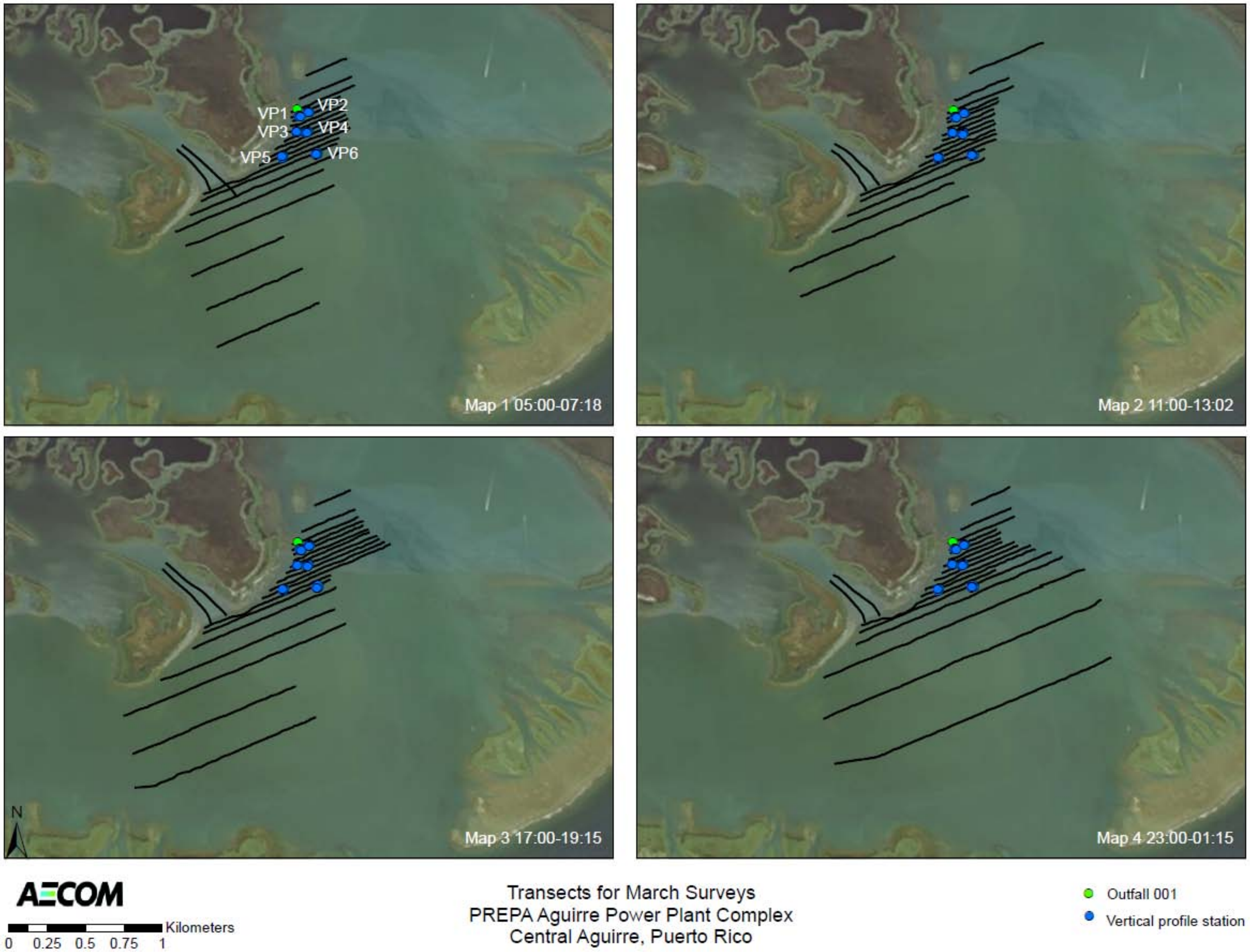


Figure 2-2. Transect and vertical profile stations occupied during winter 2012 survey

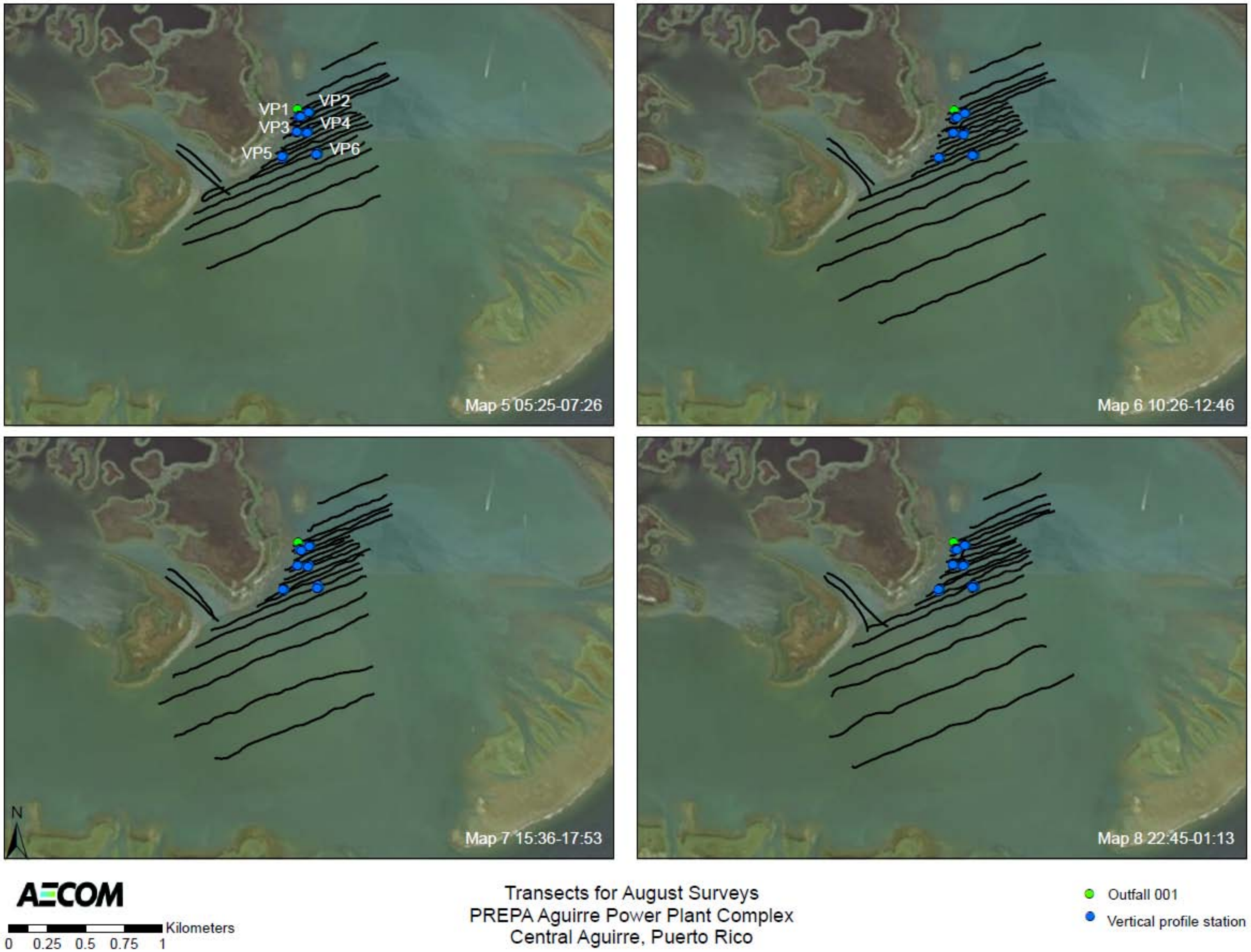


Figure 2-3. Transect and vertical profile stations occupied during summer 2012 survey

3.0 Results

A summary of the 2012 thermal plume surveys is provided below. Details of the winter and summer 2012 thermal plume surveys are included in the OSI final report, included in Appendix A.

3.1 Winter 2012 Survey

3.1.1 Temperature Moorings

Water temperature data are presented as time-series plots of near surface, mid depth, and near bottom temperatures (°F) in Figure 3-1 and statistics for each mooring are listed in Table 3-1. Water temperatures decreased with depth at each mooring location and heat dissipated progressively further from the discharge. The highest temperature recorded during the winter 2012 survey by the in-situ temperature moorings was located on the surface at Station T1 reaching 84.4°F at 17:00 (AST) and 20:35 (AST) on 13 March 2012. This station was located approximately 100 m down current of the outfall. The lowest surface temperature (78.8°F) was found at the outermost mooring, (T3 – approx. 400 m from outfall) at 12:25 (AST) on 15 March 2012 and the lowest overall water temperature recorded was on the bottom at Station T2 (approx. 250 m from outfall) reaching a low of 78.4°F at 11:55 (AST) on 15 March 2012.

Table 3-1. Winter 2012 Temperature Mooring Statistics

Near Surface (°F)							
Station	Head of Discharge	At Discharge	T1	T2	T3	T4	T5
Average	92.2	88.9	83.1	80.8	80.3	82.1	80.5
Max	96.1	91.4	84.4	81.8	81.5	83.3	81.1
Min	90.6	87.5	81.8	79.3	78.8	81.2	79.9

Mid Depth (°F)					
Average	82.0	80.2	80.5	81.6	80.1
Max	83.2	81.5	81.6	82.7	80.9
Min	80.8	78.6	78.8	80.8	79.5

Near Bottom (°F)					
Average	80.9	79.7	80.2	81.1	80.1
Max	82.6	81.0	81.3	82.3	80.8
Min	79.3	78.4	78.8	79.1	78.8

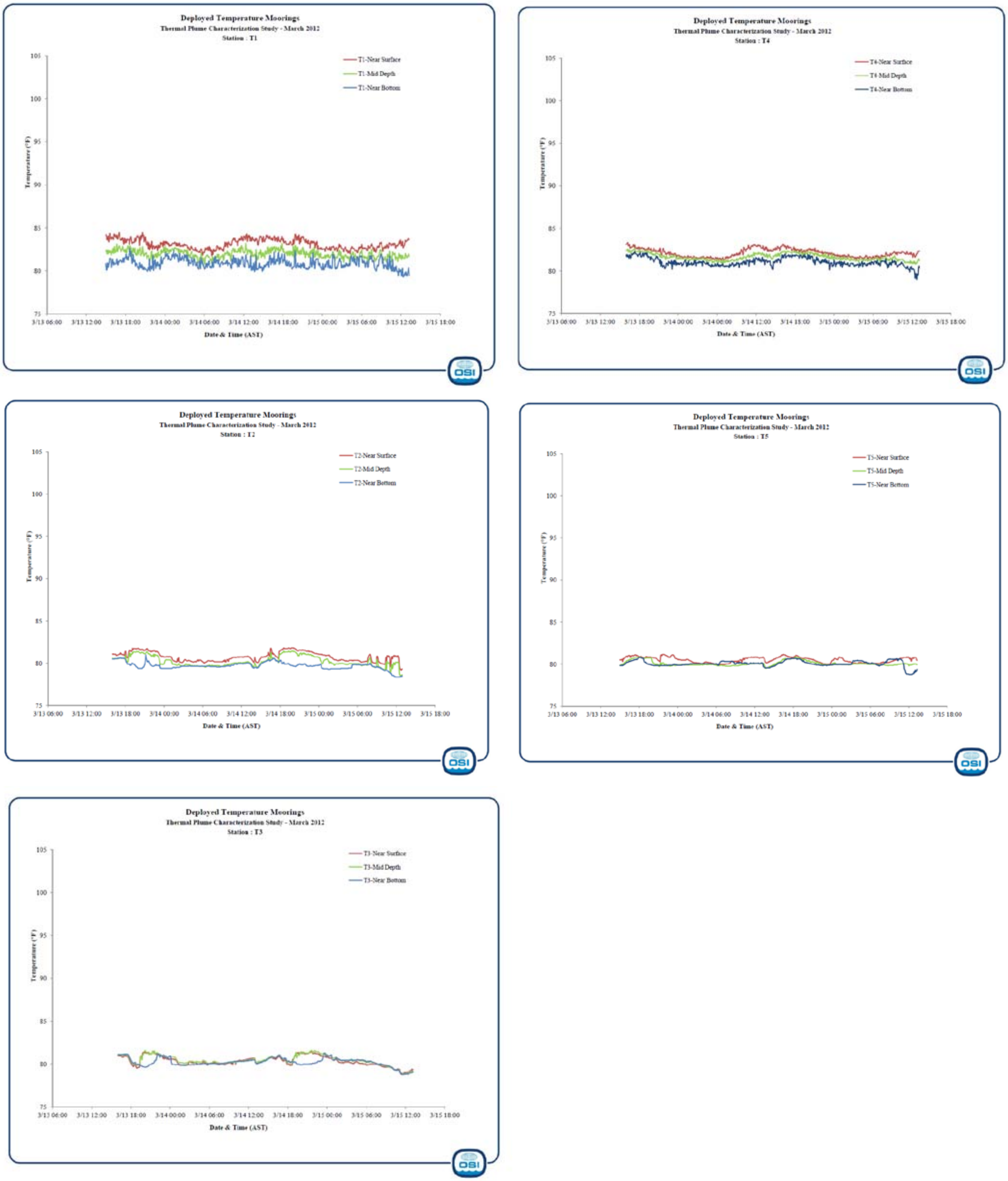


Figure 3-1. Time-series plots of near surface, mid depth, and near bottom temperatures (°F) for winter 2012 survey (Note: full-size, individual plots included in Appendix A)

In addition to the temperature moorings deployed in the Bay, a temperature sensor was deployed at the head of the discharge inside the plant. Additional water temperature data were also recorded by PREPA at the end of the discharge port at the initial point of mixing. These two datasets coupled with temperature mooring T1 data showed the dispersion of heat as the cooling water moved down the discharge pipe and was discharged into the Bay (Figure 3-2). These data revealed that the water cools on average 3.3 ºF from the head of the discharge through the discharge pipe to the outfall monitored by PREPA, approximately 4,800 feet away. The water then cools much more rapidly upon entry into the Bay, decreasing on average 5.9 ºF from the outfall to mooring T1, approximately 100 m away. At 400 m (T3), the water has cooled, on average, 8.6 ºF from the outfall and there is very little difference in temperature across depth. There is also very little difference in temperature across depth at Station T5, located 130 m to the east of the outfall, indicating that the plume hugs the western shoreline and doesn't expand very far to the east. Figure 3-2 also shows the plant's average load data across both power generating units. As expected, a direct correlation can be seen between plant load and water temperature variations.

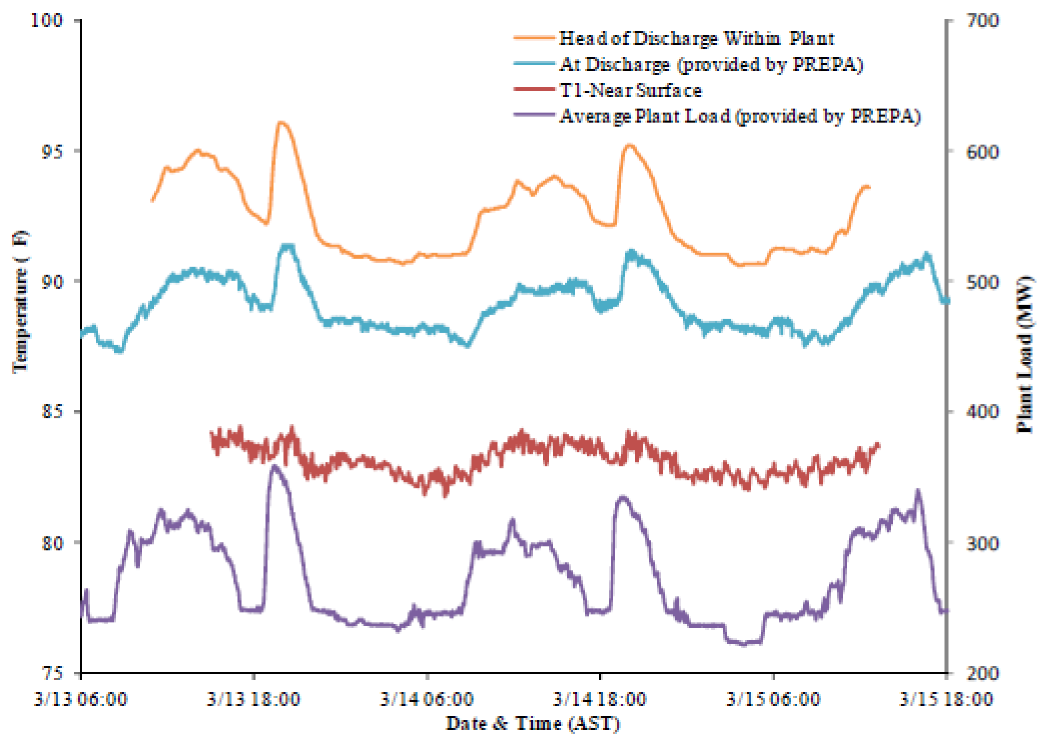


Figure 3-2. Discharge temperature and load data for winter 2012 survey

3.1.2 Thermal Plume Mapping

Four thermal plume mappings of the surface water were conducted on 14 March 2012 to characterize the horizontal dimensions and extent of the thermal discharge from the APPC discharge during the winter. The four thermal plume surveys were completed during a 24 hour tidal cycle, approximating high slack, maximum ebb, low slack, and maximum flood tidal conditions. Contoured plume drawings were produced from the temperature data collected during each tidal condition from approximately 1 foot below the surface (Figures 3-3 through 3-6).

In general, the surficial thermal plume initially migrated to the south and then to the southwest, running parallel to the closest shoreline to the west. This was most likely due to dominant wind direction from the east and discharge geometry.

Temperatures in the plume were highest during the mid-day (2^{nd} mapping) and early evening (3^{rd} mapping), correlating directly with the plant load. The greatest dispersion of the plume was noted during the maximum flood period, which occurred in the late evening. This time period corresponded with reduced plant load and low winds.

CTD vertical profiles were collected from locations chosen to be in direct line with the T-shape formation of the temperature moorings. Vertical profile temperatures during the winter survey ranged between 79.7°F and 86.1°F. The vertical profiles revealed that temperatures were higher near the surface and salinity values appeared to remain fairly stable at 29.6 (PSU) for the first three mappings and then increased to 31.2 (PSU) during the last mapping (maximum flood).

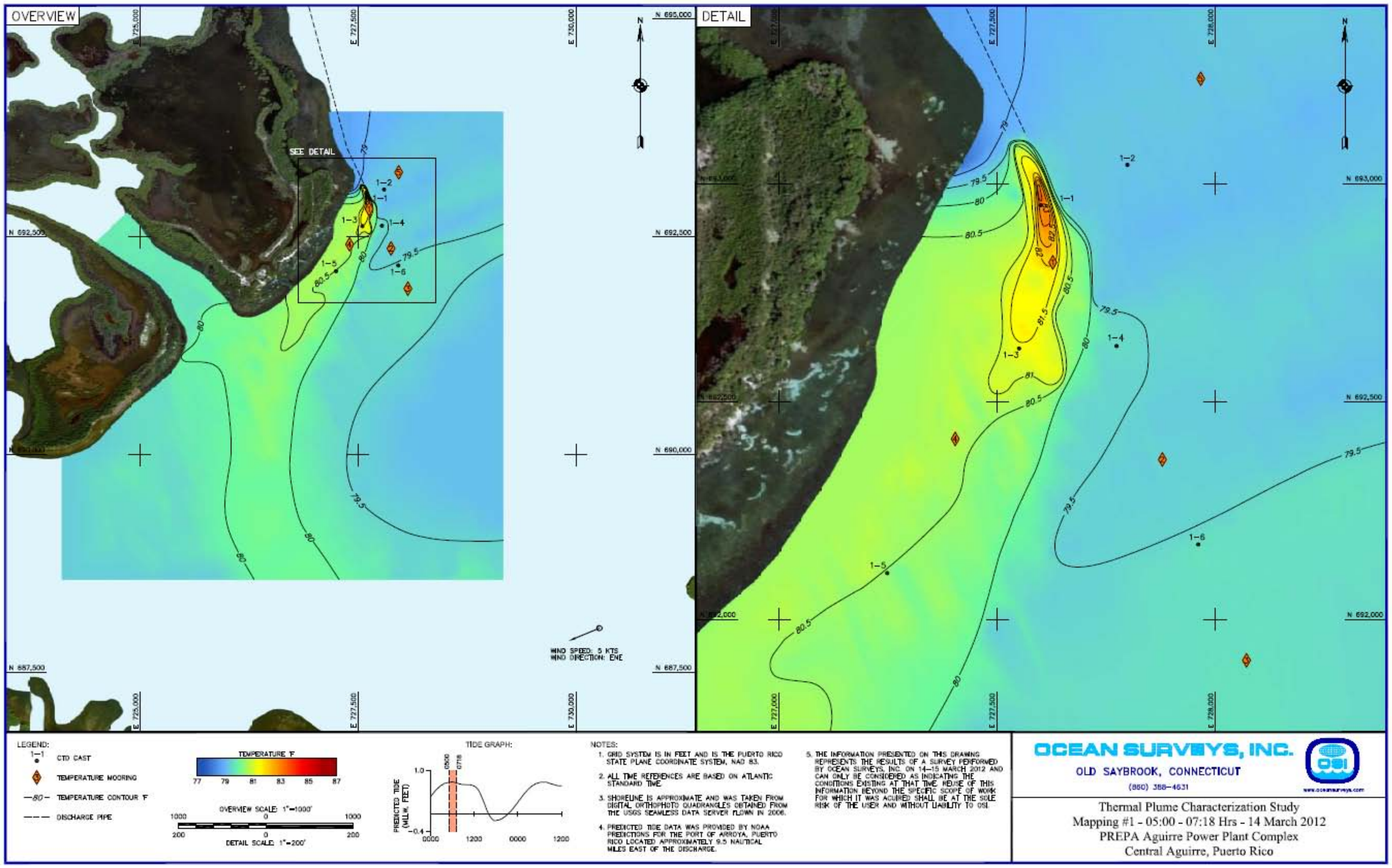


Figure 3-3. Surficial Thermal Plume Mapping #1 - Winter 2012 survey

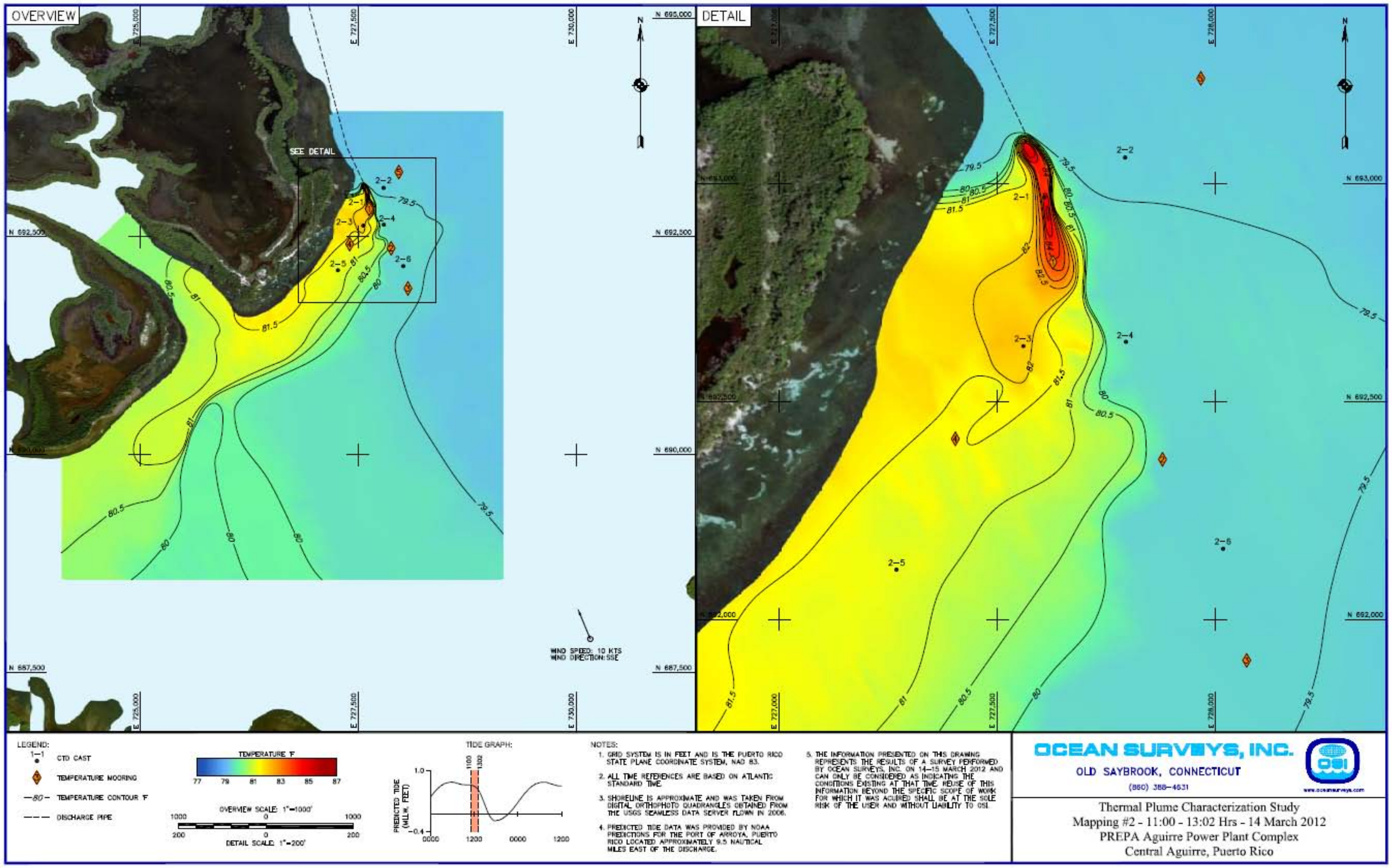


Figure 3-4. Surficial Thermal Plume Mapping #2 - Winter 2012 survey

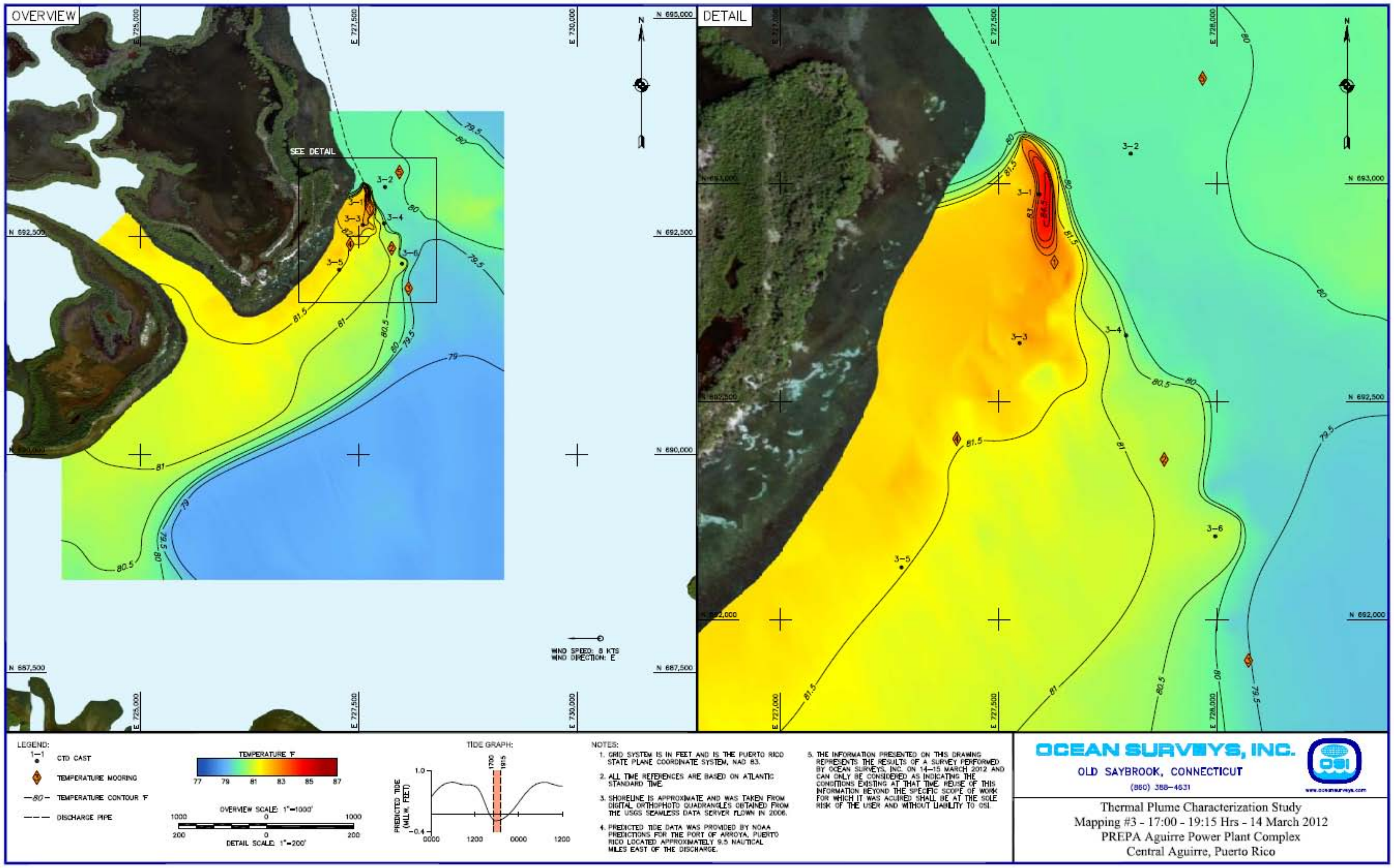


Figure 3-5. Surficial Thermal Plume Mapping #3 - Winter 2012 survey

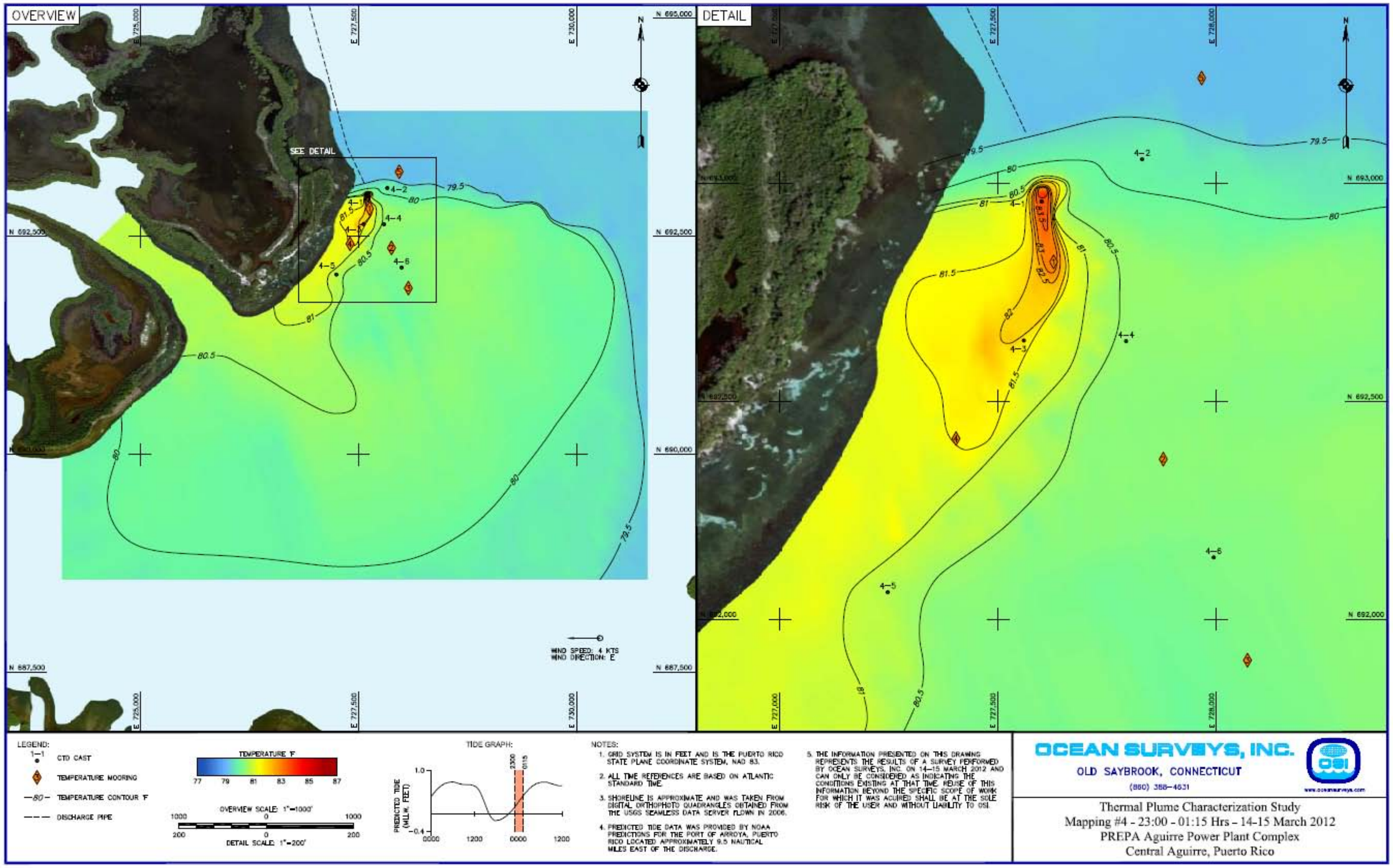


Figure 3-6. Surficial Thermal Plume Mapping #4 - Winter 2012 survey

3.2 Summer 2012 Survey

3.2.1 Temperature Moorings

Water temperature data are presented as time-series plots of near surface, mid depth, and near bottom temperatures (°F) in Figure 3-7 and statistics for each mooring are listed in Table 3-2. The highest temperature recorded by the in-situ temperature moorings was located on the surface at Station T1 (100 m down current of the outfall) reaching 88.6°F at 14:20 (AST) on 7 August 2012. The lowest surface temperature (83.6°F) was found at the outermost mooring (T3 - approx. 400 m from outfall), at 03:20 (AST) on 08 August 2012 and the lowest overall water temperature recorded was on the bottom at Station T2 (located approximately 250 m from the outfall) reaching a low of 83.3°F at 05:20 (AST) on 09 August 2012. Water temperatures decreased with depth at each mooring location and heat dissipated progressively further from the discharge.

Table 3-2. Summer 2012 Temperature Mooring Statistics

Near Surface (°F)							
Station	Head of Discharge	At Discharge	T1	T2	T3	T4	T5
Average	98.2	94.1	86.5	85.3	84.7	86.4	84.7
Max	101.8	98.8	88.5	87.0	86.9	87.8	86.6
Min	95.4	90.8	84.8	83.9	83.6	85.3	83.9

Mid Depth (°F)					
Average	85.5	84.5	84.4	85.8	84.4
Max	87.0	86.2	85.6	87.1	86.6
Min	84.2	83.6	83.7	84.8	83.6

Near Bottom (°F)					
Average	84.5	84.1	84.4	85.3	84.3
Max	86.3	85.1	85.4	86.8	85.5
Min	83.7	83.3	83.8	84.1	83.6

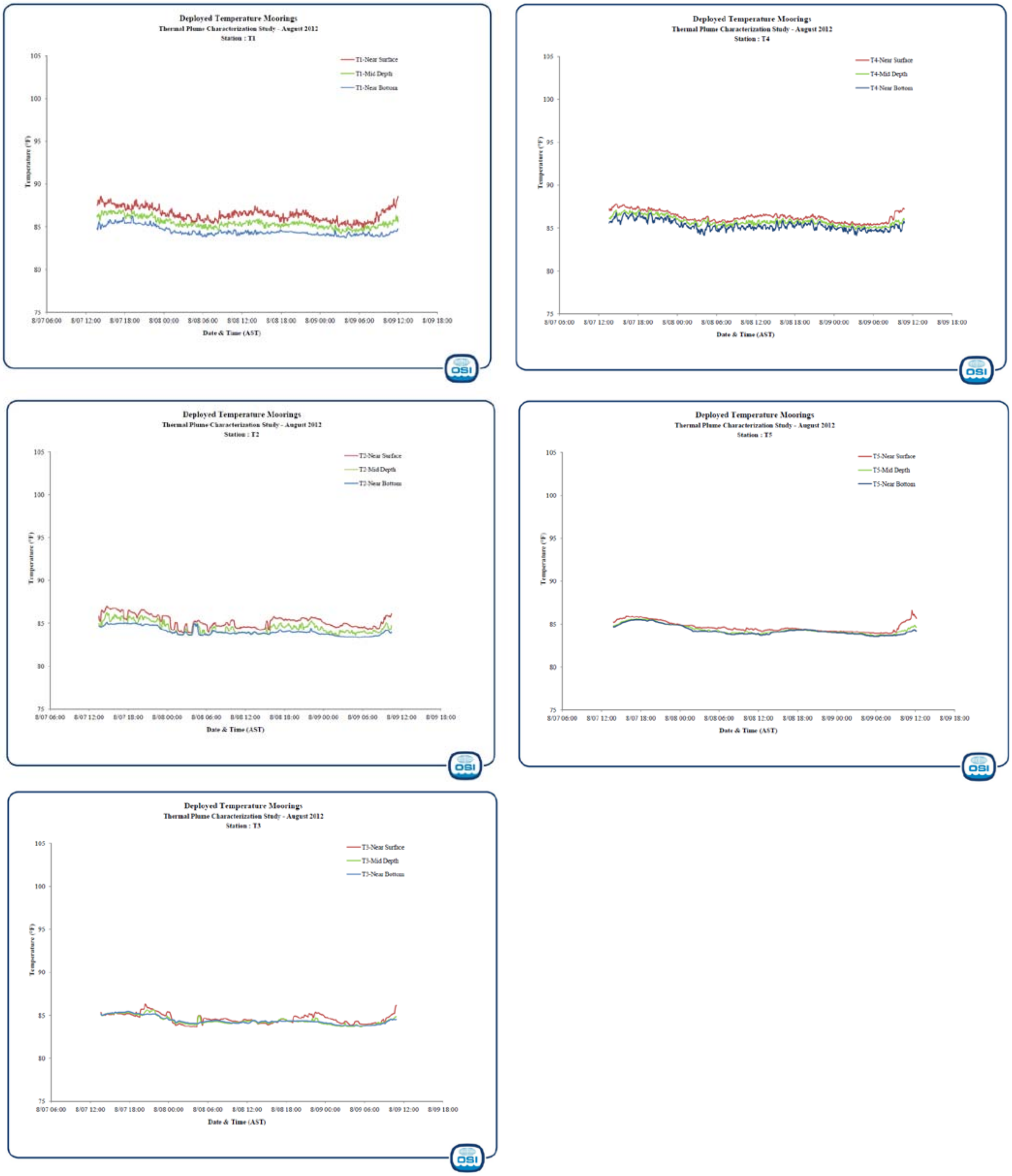


Figure 3-7. Time-series plots of near surface, mid depth, and near bottom temperatures (°F) for summer 2012 survey (Note: full-size, individual plots included in Appendix A)

In addition to the temperature moorings, a temperature sensor was deployed at the head of the discharge inside the plant property and additional water temperature data were recorded by PREPA at the end of the discharge pipe at the initial mixing zone. These two datasets coupled with temperature mooring T1 data show the dispersion of heat as the cooling water moves down the discharge pipe and enters Jobos Bay, initially mixing with the Bay water and dissipating heat within the first 300 feet from the outfall (Figure 3-8). These data revealed that the water cools about 3.3 ºF to 4.0 ºF from the head of the discharge to the outfall monitored by PREPA approximately 4,800 feet away. The water then cools much more rapidly decreasing around 5.8 ºF to 7.6 ºF from the outfall to the T1 mooring, approximately 310 feet away. Also presented in Figure 3-8 is the plant's total load data from both power generating units. As expected, a direct correlation can be seen between plant load and water temperature variations.

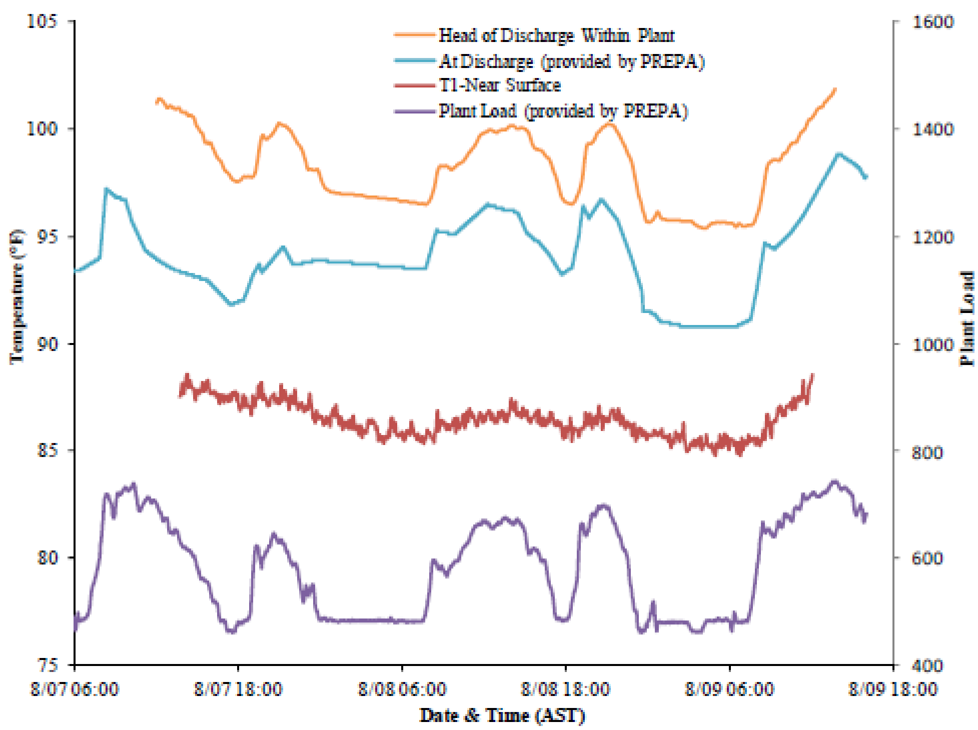


Figure 3-8. Discharge temperature and load data for summer 2012 survey

3.2.2 Thermal Plume Mapping

Four thermal plume mappings of the surface water were conducted on 8 August 2012 to characterize the horizontal dimensions and extent of the thermal discharge from the APPC discharge during the summer. The four thermal plume surveys were completed over a 24 hour tidal cycle, approximating high slack, high slack/ebb, low slack, and maximum flood tidal conditions. Contoured plume drawings were produced from the temperature data collected during each tidal condition from approximately 1 foot below the surface (Figures 3-9 through 3-12).

Similar to the plumes observed during the winter survey, in general, the surficial thermal plume initially migrated to the south and then to the southwest, running parallel to the western shoreline. This was most likely due to dominant wind direction from the east and discharge geometry.

Temperatures in the plume were highest during the mid-day (2nd mapping) and early evening (3rd mapping), correlating directly with the plant load. The greatest dispersion of the plume was noted during the maximum flood period, which occurred in the late evening. This time period corresponded with reduced plant load and low winds.

CTD vertical profiles were collected from locations chosen to be in direct line with the T-shape formation of the temperature moorings. Vertical profile temperatures during the summer survey ranged between 83.6°F to 88.1°F. The vertical profiles revealed temperatures were higher near the surface and salinity values appeared to remain fairly stable at 34.4 (PSU).

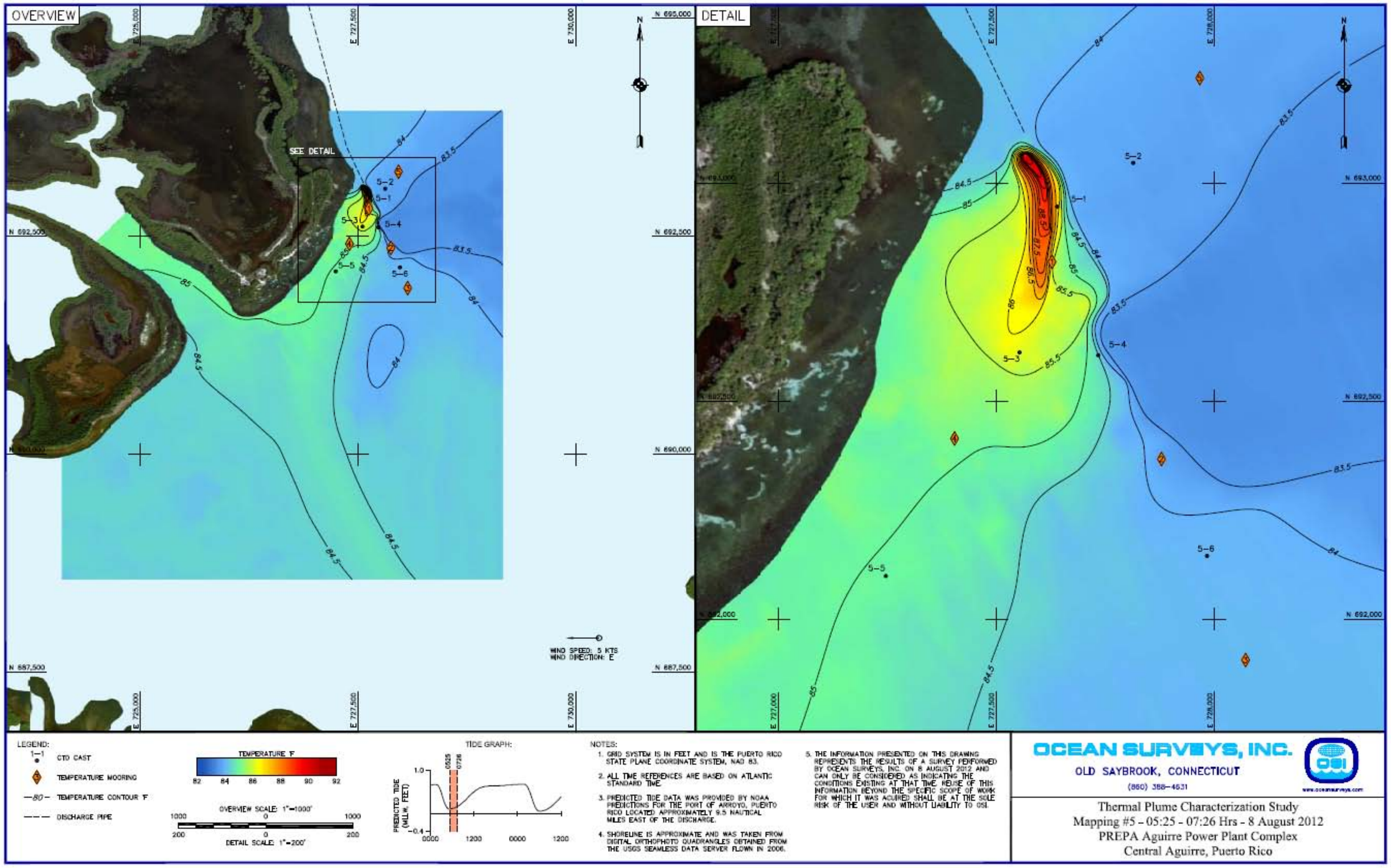


Figure 3-9. Surficial Thermal Plume Mapping #1 - Summer 2012 survey

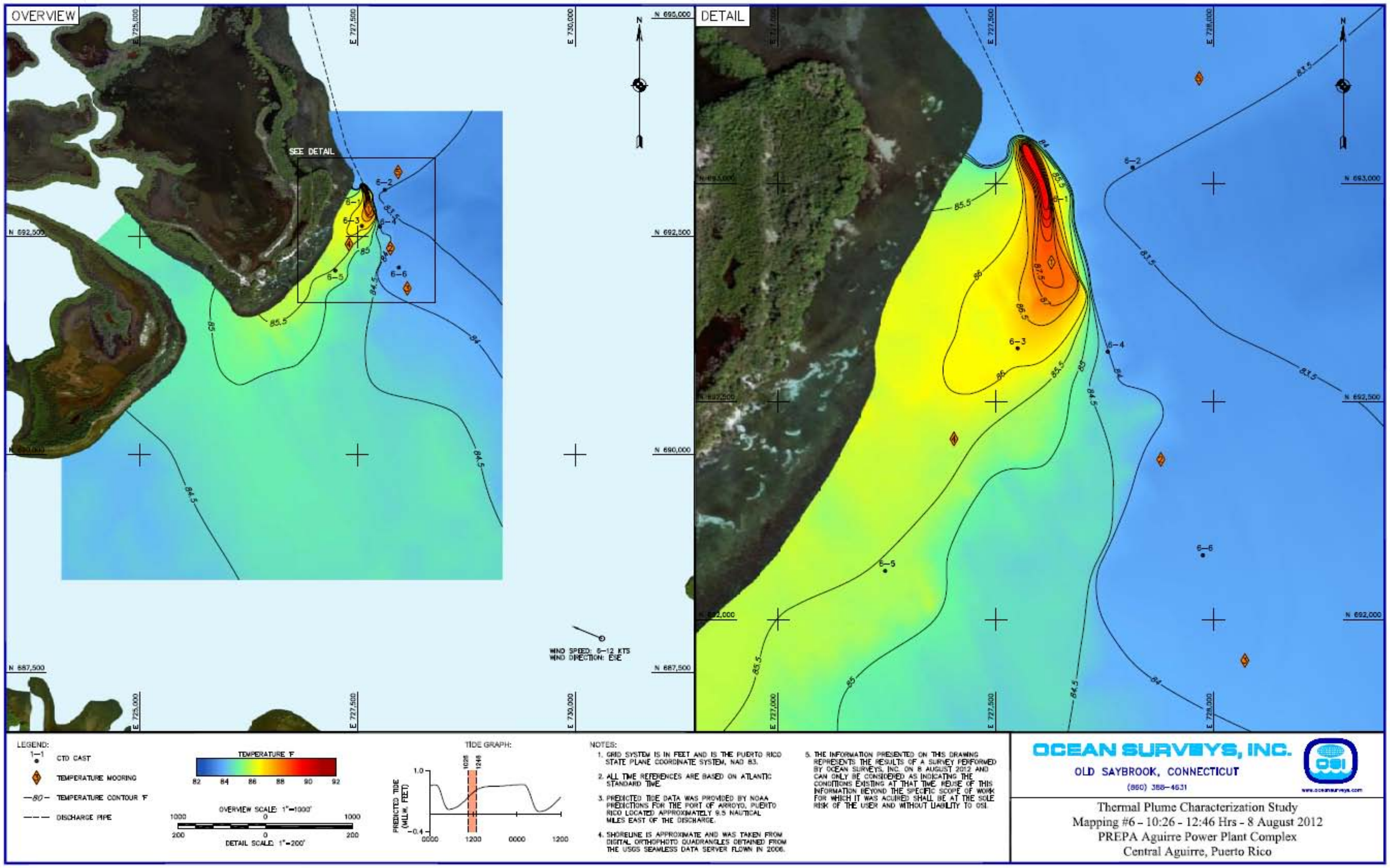


Figure 3-10. Surficial Thermal Plume Mapping #2 - Summer 2012 survey

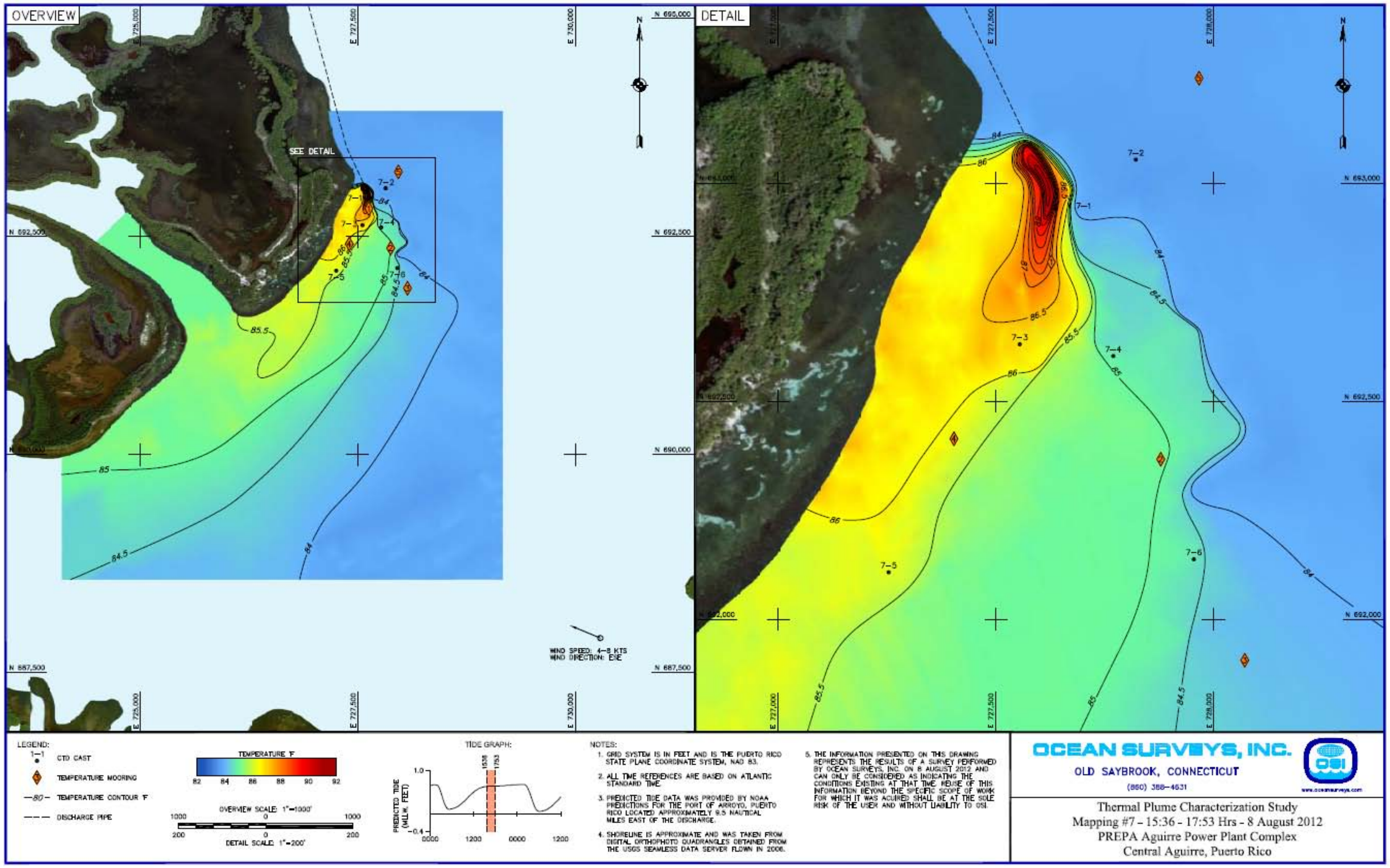


Figure 3-11. Surficial Thermal Plume Mapping #3 - Summer 2012 survey

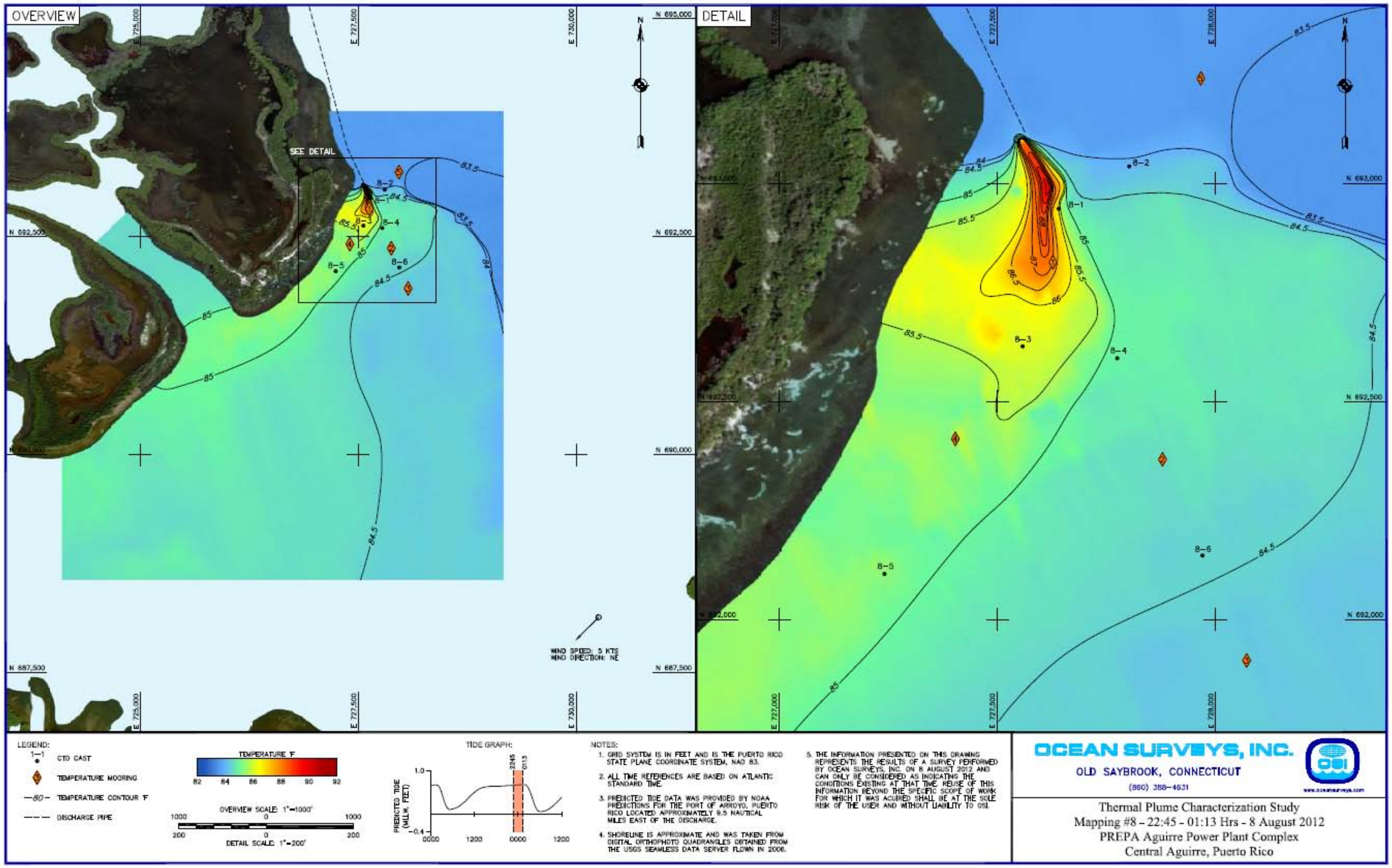


Figure 3-12. Surficial Thermal Plume Mapping #4 - Summer 2012 survey

4.0 Summary

Condition 23 of the APPC 2010 NPDES permit required the implementation of a one year monitoring program and dye study to validate the mathematical model prepared by Washington Group (2005) and verify the behavior of the plume within the mixing zone. PREPA alternatively proposed to conduct a thermal plume mapping study to characterize the APPC thermal discharge plume. While both a dye study and a thermal plume study can produce the required data to validate the mathematical thermal model, according to PRWQS Section 1305.9, the thermal plume study would collect temperature data that are directly comparable to the results of the mathematical thermal model. In addition, specific tide, ambient temperature, and discharge conditions can be targeted by the thermal plume study to mimic the modeled scenarios.

The March and August 2012 field investigations successfully described the APPC thermal discharge plume under winter and summer conditions. Based on the results of the two surveys, the near field dispersion characteristics of the APPC discharge plume was relatively consistent across seasons and tidal cycles. The major difference that was observed between the winter and summer surveys was the initial background water temperature recorded. During the winter survey, the initial background temperature was approximately 79.0°F and in the summer the background temperature was higher(83.5 °F). The horizontal plume tracking data from both surveys indicated the plume flowed south-southwest from the discharge and along the Punta Colchones shoreline. The plume also appeared to be confined, for the most part, to the surface waters with some intrusion to mid-depth. Even at the closest moored temperature station to the discharge (T1), there was little evidence of a temperature increase near the bottom. The data also indicated that the plume was not very widespread. Very little change in temperature was noted at Stations T3 and T5, located 400 m southeast and 125 m east of the discharge, respectively, further indicating that the plume was confined to the western shoreline.

Tidal cycle appeared to have little effect on the characteristics of the plume. Instead, wind conditions and plant load appeared to have the strongest influence on the magnitude and shape of the plume during both the summer and winter. Power plant load played a significant role in the initial temperatures recorded near the outfall, while wind speed and direction appeared to be the dominant force shaping the thermal plume within the Bay at large. Temperatures in the plume increased during the mid-day and early evening in direct correlation to plant load (energy needs) during the middle and early evening portions of the day.

While the near field of the plume was relatively consistent across seasons, the far field of the plume appeared more widespread during the winter survey with the plume appearing to extend into the shallow waters between Punta Colchones and Cayo Puerca and along the Cayo Puerca shoreline. This was likely due to the fact that wind gusts were higher and more sustained in March, compared to August (Weather Underground, 2012).

Based on the results of the thermal plume mapping and the temperature monitoring conducted by PREPA during the March and August 2012 surveys, water temperatures at the edge of the mixing zone did not exceed the interim mixing zone (IMZ) daily maximum temperature limitation of 90°F (32.2°C), as stipulated in the Puerto Rico Water Quality Standards Regulation (PRWQSR, 2010). The next step in the final authorization of a mixing zone, according to PRWQS Section 1305.9 (EQB 2010), requires calibration and validation of the mathematical models used to define the IMZ, which requires a comparative analysis between the measured values in the sampling program and the values calculated by the model for corresponding points throughout the periphery of the mixing zone. Model calibration is presented and discussed in Washington Group (2005). Validation requirements presented in EQB (2010) state: “The model in which 90 percent of the calculated values are equal or less than the ones obtained through the sampling program shall be validated.” Formal validation of the model was not performed as a part of this effort however, the general configuration of the plume and mixing zone were similar in shape and extent to those presented in the modeling study and associated field effort (Washington Group 2005).

Appendix A

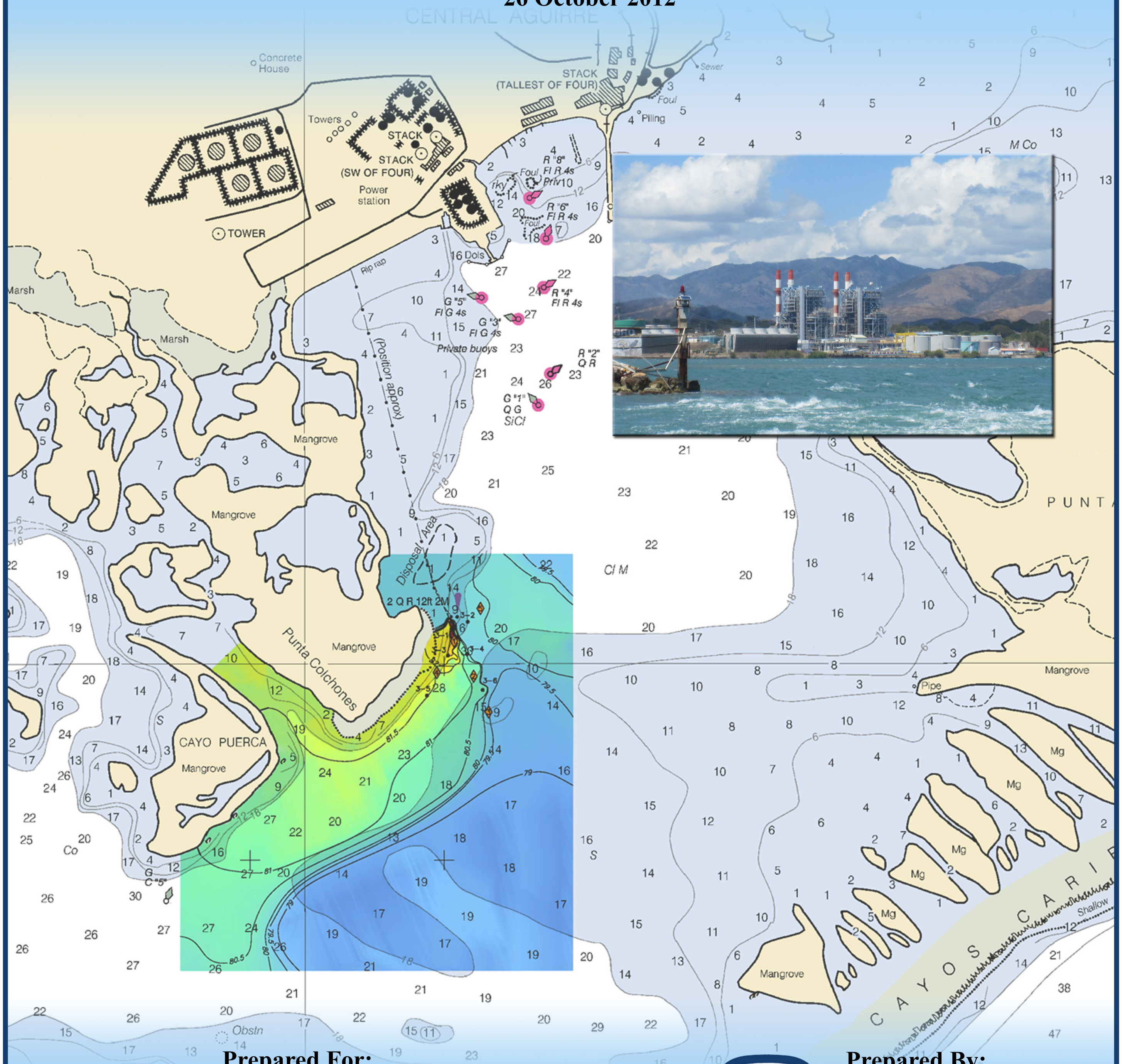
OSI Final Report

Final Report

Thermal Plume Characterization Study

PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico

OSI Report #11ES025
26 October 2012



Prepared For:
AECOM
250 Apollo Drive
Chelmsford, MA 01824

Prepared By:
Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

FINAL REPORT

THERMAL PLUME CHARACTERIZATION STUDY

PREPA AGUIRRE POWER PLANT COMPLEX
CENTRAL AGUIRRE, PUERTO RICO

OSI Report No. 11ES025

Prepared For: AECOM
250 Apollo Drive
Chelmsford, MA 01824

Prepared By: Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475

26 October 2012

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Appendices:

FINAL REPORT

THERMAL PLUME CHARACTERIZATION STUDY

PREPA AGUIRRE POWER PLANT COMPLEX
CENTRAL AGUIRRE, PUERTO RICO

1.0 INTRODUCTION

During the periods of 12 March 2012 through 16 March 2012 and 06 August 2012 through 10 August 2012, Ocean Surveys, Inc. (OSI) conducted detailed field investigations of the thermal plume generated by the Aguirre Power Plant Complex discharge in Central Aguirre, Puerto Rico. The overall program is designed to characterize the thermal plume from the PREPA power station's discharge during both winter and summer conditions through both deployed temperature moorings and real-time boat-based transect surveys. The March 2012 survey recorded thermal plume characteristic under winter conditions. The August 2012 survey captured the thermal plume characteristics under summer conditions.

The following paragraphs outline the operational aspects of the field program including a summarized schedule of operations, the equipment and methods employed, and a presentation of the data collected.

1.1 Project Summary

The OSI data acquisition program consisted of two major components. The first component involved the installation of five *in situ* temperature moorings to document water temperatures at near surface, mid depth, and near bottom near the mouth of the discharge in Bahia De Jobos (Figure 1). In addition, a temperature sensor was placed at the head of the plant's discharge within the power plant. The second component was to conduct four thermal plume mappings over one complete twenty-four hour tidal cycle. The mapping program documented both the horizontal and vertical temperature plumes that emanated from the plant's discharge.

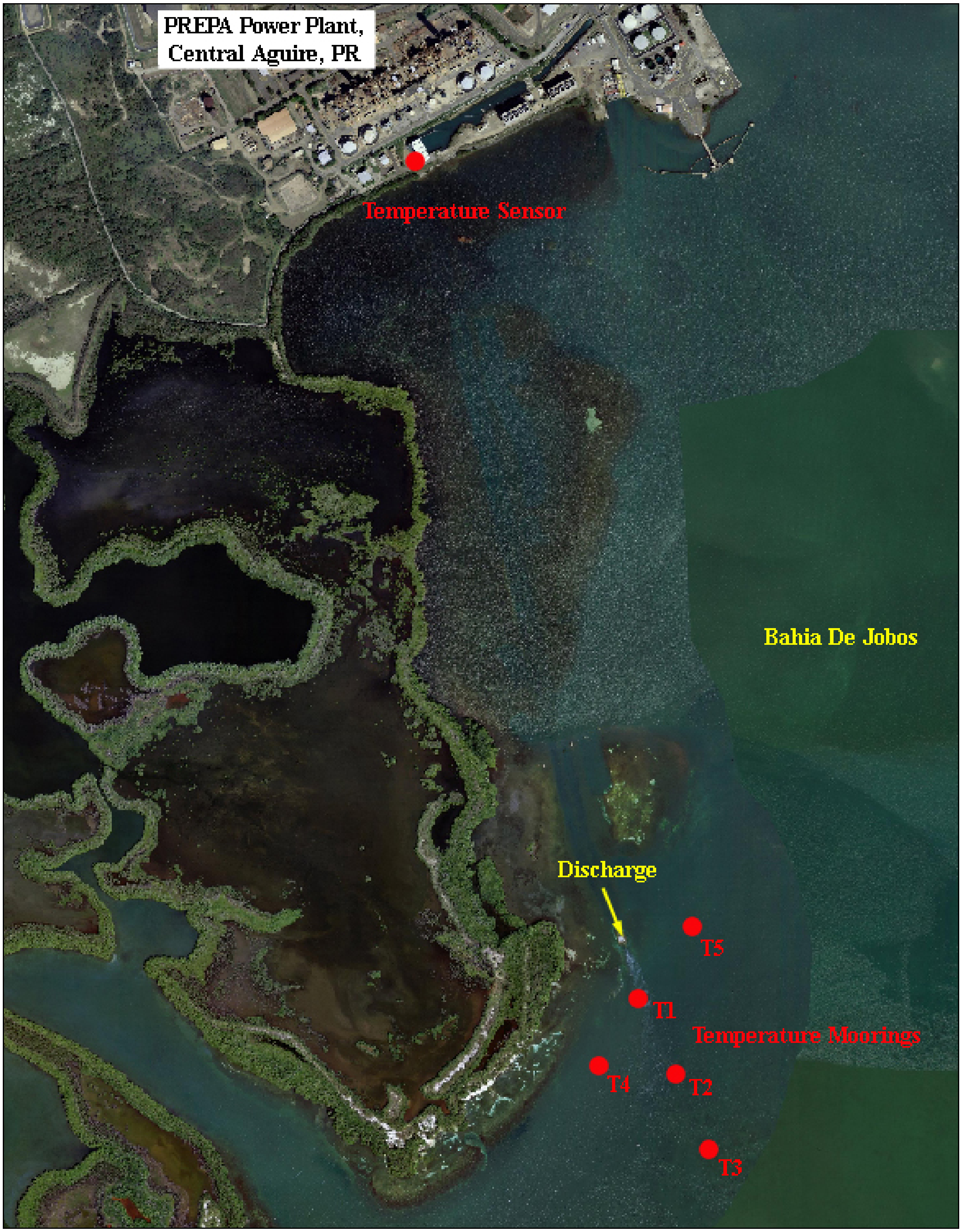


Figure 1. Temperature mooring locations.

In order to accurately document the tidal and daily fluctuations of the plume, OSI timed the mappings of the investigation to coincide with the general tidal conditions of the area along with specific times of day. All temperature sensors used on this project were calibrated in a temperature bath at OSI's Old Saybrook, CT facility prior to this study. As a result, all water temperature data were post processed to include an adjustment by a linear calibration curve. The resulting data have an accuracy of within 0.1ºF.

2.0 FIELD OPERATIONS SUMMARY

2.1 Field Crew, Survey Vessel, & Navigation

All fieldwork was conducted aboard a small center console vessel provided by PREPA. OSI equipped the vessel with a DMS 212 differential global positioning system (DGPS) receiver and staffed it with a two-person OSI field team consisting of a Project Manager/Scientist and a Field Engineer. During the real-time temperature mappings, the vessel was also equipped with an OSI Thermal Monitoring System and YSI 6920 conductivity/temperature/depth (CTD) vertical profiler.

A DGPS interfaced with the PC-based hydrographic software package HYPACK was used for survey-vessel navigation and positioning. The global positioning system consists of 24 earth-orbiting satellites, which broadcast radio signals to the surface. These signals are used by the GPS receiver to calculate its position based on the signal time delay. Four or more satellite signals are required to accurately calculate the receiver's position. Differential correctors, used to increase vessel position accuracy to ±1 meter, were received from a USCG beacon transmitter via a radio link. The geodetic positions derived from the DGPS system were converted to the Puerto Rico State Plane Coordinate System (NAD83, feet) for survey operations and preparation of final products.

OSI's navigation system consists of a portable personal computer with HYPACK software installed. Geodetic coordinate information from the DGPS was updated at one-second intervals and input to the navigation computer, which processed the geodetic position data into State Plane Coordinates used to guide the survey vessel. The incoming data were logged on disk and processed in real time allowing the vessel position to be displayed on a video monitor and compared to pre-plotted tracklines and positions as the survey progresses. Digitized shoreline and the locations of existing structures, buoys, and control points can also be displayed on the monitor in relation to the vessel position. This system provides a highly accurate visual representation of survey vessel location in real time, combined with data logging capabilities and post-survey data processing and plotting.

The manufacturer's equipment specification sheets for all survey equipment used in this field program are available in Appendix 1.

2.2 Field Schedule

Field operations were conducted from in March and August of 2012. A detailed schedule of field operations is summarized below:

March:

- **12 March** - The field crew traveled to Puerto Rico, picked up supplies and went to the plant for a brief check in.
- **13 March** –Arrived at plant and attended a safety meeting. Installed all *in situ* moorings and sensors.
- **14 March –** Conducted four thermal plume mappings spaced approximately 6 hours apart.
- **15 March-** Recovered all *in situ* temperature moorings. De-mobilized vessel and secured equipment.
- **16 March**- Traveled back to Connecticut.

August:

- **06 August** - The field crew traveled to Puerto Rico, picked up supplies.
- **07 August** - Arrived at plant and attended a safety meeting. Installed all *in situ* moorings and sensors.
- **08 August** - Conducted four thermal plume mappings spaced approximately 6 hours apart.
- **09 August** - Recovered all *in situ* temperature moorings. De-mobilized vessel and secured equipment.
- **10 August -** Traveled back to Connecticut

2.3 *In Situ* Instrumentation and Moorings

During each trip, all *in situ* temperature moorings were deployed for a period of two days to encompass the real-time thermal mapping surveys. The instruments were set to record at 5-minute intervals. The layout of the mooring locations is shown in Figure 1 and the coordinates are presented in Table 1. A total of five (5) temperature moorings were deployed. The moorings were placed near the mouth of the discharge within the Bahia De Jobos. One mooring was placed directly in front of the discharge while the remaining four moorings were placed in a "T" formation at 500-foot spacing (Figure 1). Each mooring consisted of three Onset Hobo Water Temperature Pro v2 data loggers positioned at 1 foot below the surface, mid depth, and 1 foot above the bottom. In addition, OSI also deployed one data logger at the head of the plant's discharge within the power plant to collect water temperature prior to passing through the discharge pipe. In addition, PREPA provided OSI with temperature data collected directing in front of the discharge pipe at the initial mixing point.

Table 1. *In Situ* Temperature Moorings

Station Designation	March 2012		August 2012	
	Easting*	**Northing***	**Easting***	**Northing***
T1	727527	692819	727630	692817
T2	727879	692367	727881	692371
T3	728072	691906	728073	691907
T4	727404	692414	727403	692407
T5	727967	693241	727965	693240

* Puerto Rico State Plane (NAD83, ft)

2.4 Thermal Plume Mapping

Real-time thermal plume mappings were completed four times on 15 March 2012 coinciding approximately with high slack, maximum ebb, low slack, and maximum flood tidal conditions. Similarly, four mappings were completed on 8 August 2012 coinciding with low slack, maximum flood, high slack, and maximum ebb tidal conditions. In addition, during both trips, the mappings were scheduled to fixed periods of the day. The mappings were completed at early mooring, mid day, late afternoon/evening, and midnight. This scheduling allowed for a complete survey of the discharge under a variety of daily conditions.

For horizontal spatial plume mappings, water temperature data were measured using OSI's Thermal Monitoring System interfaced to a DGPS navigational software system aboard the survey vessel. The OSI Thermal Monitoring System consists of a central processing unit with hard wire thermistor inputs. OSI uses YSI Model 44036 Series epoxy encapsulated thermistor probes with a temperature range of -112ºF to 167ºF and an accuracy of ±-0.1ºF for the full range.

OSI utilized two thermistors, a primary and backup, to ensure high quality redundant data recovery. The thermistors were located on the side of the survey vessel, directly under the DGPS antenna, at a depth of one foot below the surface of the water. Data from the probes were uploaded at 2 Hz into the navigational computer system and combined with the x and y positioning data. The horizontal mapping operations were completed over the course of eight mappings (Table 2), utilizing 19-21 transects during each mapping.

Table 2. Thermal Plume Mapping Times

Mapping Number	Date	Mapping Period (AST*)
1	14 March	05:00-07:14
2	14 March	11:00-12:57
3	14 March	17:00-19:08
4	14 March	23:00-01:06
5	08 August	05:25-07:26
6	08 August	10:26-12:46
7	08 August	15:36-17:53
8	08 August	22:45-01:13

* Atlantic Standard Time

3.0 PRESENTATION AND DISCUSSION

3.1 *In Situ* Temperature Moorings

Water temperature data from the fixed moorings are presented as time-series plots of near surface, mid depth, and near bottom temperatures (°F) in Appendix 2. In March, the highest temperature recorded by the *in situ* temperature moorings was located on the surface at Station T1 reaching upwards of 84.4°F at 17:00 Atlantic Standard Time (AST) and 20:35 (AST) on 13 March 2012. This station is located directly down current from the outfall. The lowest surface temperature (78.8°F) was found at the outermost mooring, (T3) at 12:25 (AST) on 15 March 2012 and the lowest water temperatures recorded over the entire program was on the bottom at Station T2 reaching a low of 78.4°F at 11:55 (AST) on 15 March 2012. Statistics for each mooring during the March 2012 survey are listed below in Table 3. Water temperatures decreased with depth at each mooring location and heat dissipated progressively further from the discharge.

Table 3. Temperature Mooring Statistics - March 2012

Near Surface (ºF)							
Station	**Head of Discharge**	**At Discharge**	**T1**	**T2**	**T3**	**T4**	**T5**
Average	92.2	88.9	83.1	80.8	80.3	82.1	80.5
Max	96.1	91.4	84.4	81.8	81.5	83.3	81.1
Min	90.6	87.5	81.8	79.3	78.8	81.2	79.9

Mid Depth (ºF)					
Average	82.0	80.2	80.5	81.6	80.1
Max	83.2	81.5	81.6	82.7	80.9
Min	80.8	78.6	78.8	80.8	79.5

Near Bottom (ºF)					
Average	80.9	79.7	80.2	81.1	80.1
Max	82.6	81.0	81.3	82.3	80.8
Min	79.3	78.4	78.8	79.1	78.8

*Note: Water depths of Mid Depth and Near Bottom temperature sensors varied based on individual stations.

In August, the highest temperature recorded by the *in situ* temperature moorings was located on the surface at Station T1 reaching upwards of 88.6°F at 14:20 (AST) on 7 August 2012.

The lowest surface temperature (83.6°F) was found at the outermost mooring, (T3) at 03:20 (AST) on 08 August 2012 and the lowest water temperatures recorded over the entire program was on the bottom at Station T2 reaching a low of 83.34°F at 05:20 (AST) on 09 August 2012. Statistics for each mooring during the August 2012 survey are listed below in Table 4.

Table 4. Temperature Mooring Statistics - August 2012

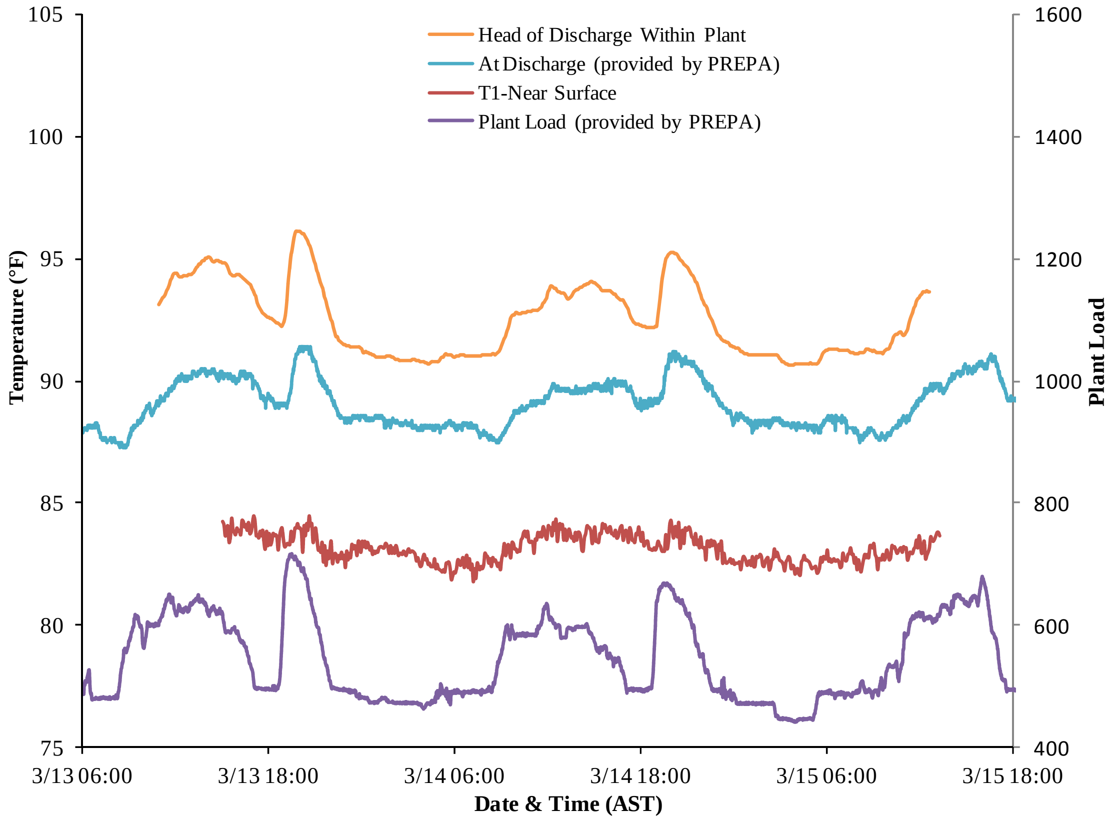
Near Surface (ºF)							
Station	**Head of Discharge**	**At Discharge**	**T1**	**T2**	**T3**	**T4**	**T5**
Average	98.2	94.1	86.5	85.3	84.7	86.4	84.7
Max	101.8	98.8	88.5	87.0	86.9	87.8	86.6
Min	95.4	90.8	84.8	83.9	83.6	85.3	83.9

Mid Depth (ºF)					
Average	85.5	84.5	84.4	85.8	84.4
Max	87.0	86.2	85.6	87.1	86.6
Min	84.2	83.6	83.7	84.8	83.6

Near Bottom (ºF)					
Average	84.5	84.1	84.4	85.3	84.3
Max	86.3	85.1	85.4	86.8	85.5
Min	83.7	83.3	83.8	84.1	83.6

*Note: Water depths of Mid Depth and Near Bottom temperature sensors varied based on individual stations.

In addition to the temperature moorings, OSI deployed a temperature sensor at the head of the discharge inside the plant property. Additional water temperature data were recorded by PREPA at the end of the discharge at the initial mixing zone. These two datasets coupled with OSI's temperature mooring T1 data show the dispersion of heat as the cooling water moves down the discharge pipe and initial mixing and dissipating heat within the first 300 feet from the discharge (Figure 2). These data revealed that the water cools about 3.3 ºF to 4.0 ºF from the head of the discharge to the initial mixing point monitor by PREPA nearly 4,930 feet away. The water then cools much more rapidly decreasing around 5.8 ºF to 7.6 ºF from the initial mixing point to OSI's T1 moorings approximately 310 feet away. Also overlain in Figure 2 is the plant's total load data from both power generating units. As expected, a direct correlation can be seen between plant load and water temperature variations.



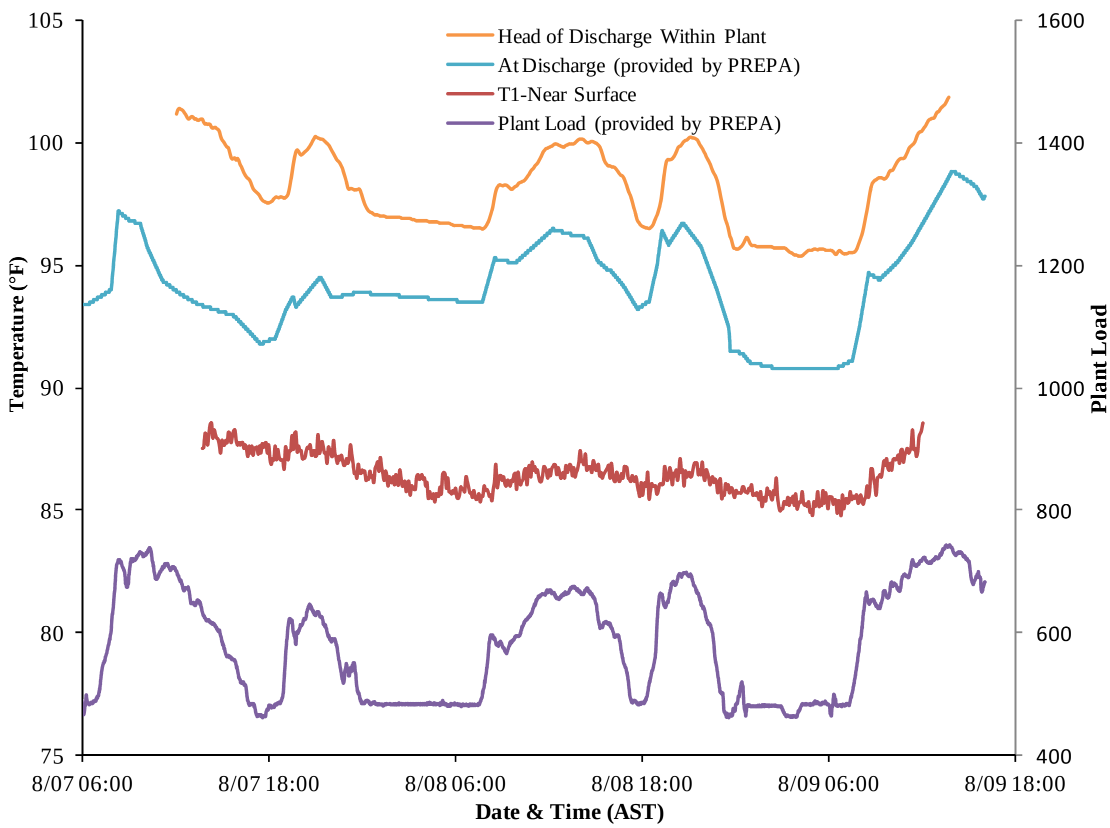


Figure 2. Discharge temperature data, March 2012 & August 2012.

3.2 Real-Time Thermal Plume Surveys

OSI conducted eight thermal plume surveys on 14 March 2012 and on 08 August 2012 to characterize the overall dimensions and extent of the thermal discharge from the PREPA Central Aguirre Power Plant’s discharge. Plumes were primarily mapped horizontally using a vessel-mounted temperature system at a depth of 1 foot while additional measurements were collected periodically along vertical profiles throughout each survey event.

3.2.1 Vessel Mounted Temperature Plume Surveys

The thermal plumes, generated from the vessel-mounted temperature system data collected in March and August 2012, are available as contoured plume drawings in Appendix 3. While each plume has small distinct differences, overall the thermal plumes migrated directly to the south-southwest and then more to the southwest running parallel to the closest shoreline to the northwest. This migration pattern was most likely due to both dominant winds from the east and discharge geometry. Temperatures in the plume increased during the mid day (2nd & 6th mapping) and early evening (3rd & 7th mapping) as a direct correlation to plant load needs during the middle and early evening portions of the day. The fourth and eighth mappings were conducted last and produced the most dispersed plume. Not only were plant loads reduced at this hour of the day but winds had died down considerably and the far-field plume was evident over a large portion of the bay. Data files from the horizontal plume surveys are included with the attached digital deliverable.

3.2.2 CTD Vertical Profiles

Data from the CTD vertical profiles collected during the thermal plume surveys are presented in Appendix 4. Each vertical profile is labeled with a mapping number (1-8) and a location number (1-6) and has been plotted on each individual plume map. Profile locations were chosen to be in direct line with the T-shape formation of the temperature moorings. Vertical profile temperatures during the March 2012 survey ranged between 79.7°F to 86.1°F while the August 2012 survey revealed warmer temperatures between 83.6°F to 88.1°F. The vertical profiles revealed temperatures were generally higher near the surface. During the March 2012 survey, salinity values appeared to remain fairly stable at 29.6 (PSU) for the first three mappings and then increase to 31.2 (PSU) during the last mapping. Salinity remained fairly stable during the August 2012 survey at around 34.4 (PSU). Data files of the vertical profiles are included with the attached digital deliverable.

4.0 SUMMARY

The March and August 2012 field investigation successfully recorded the thermal plume emanating from the PREPA Central Aguirre Power Station under winter and summer conditions. The field techniques included deployed temperature moorings, vessel mounted thermistors for horizontal plume mappings, and CTD vertical profiles. While each plume had subtle differences, the near field mixing zone was very similar in nature throughout the entire tidal cycle. Power plant load played a strong role in the initial temperatures seen near the discharge pipe. Meanwhile, wind speed and direction appeared to be the dominant force shaping the thermal plume within the Bahia De Jobos during both the summer and winter investigations.

The thermal plumes mappings that were conducted in the winter and summer of 2012, shared many of the same characteristics. Both summer and winter plume mappings where mostly driven by wind speed and direction and in both seasons the thermal plume migrated to south-southwest. The major difference that was observed between the winter and summer was the initial background temperature recorded. During the winter plume mapping the initial background temperature was approximately 79.0 °F and in the summer the background temperature rose approximately 4.5 °F to 83.5 °F.

APPENDIX 1

MANUFACTURER'S EQUIPMENT SPECIFICATIONS

HOBO® U22 Water Temp Pro v2
(Part # U22-001)

Inside this package:

- HOBO U22 Water Temp Pro v2 logger

Thank you for purchasing a HOBO data logger. With proper care, it will give you years of accurate and reliable measurements.

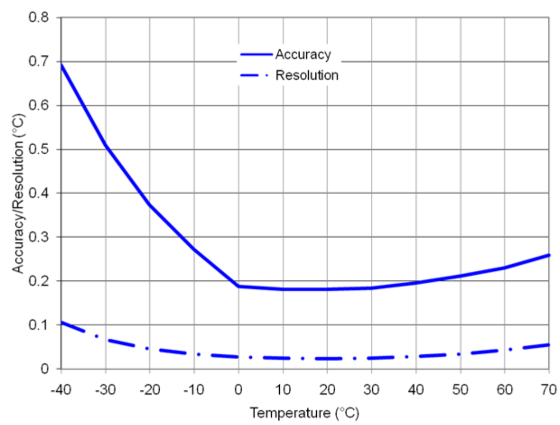
The HOBO Water Temp Pro v2 logger is designed with a durable, streamlined, UV-stable case for extended deployments measuring temperature in fresh or salt water. The small size of the logger allows it to be easily mounted and/or hidden in the field. It is waterproof up to 120 m (400 feet) and rugged enough to withstand years of use, even in stream conditions. It has enough memory to record over 42,000 12-bit temperature measurements.

The logger uses an optical USB communications interface (USB-Optic Base Station, Part # BASE-U-4, with COUPLER2-C) for launching and reading out the logger. The optical interface allows the logger to be offloaded without compromising the integrity of the seals. The USB compatibility allows for easy setup and fast downloads.

HOBOware® software is also required for logger operation. Visit www.onsetcomp.com for compatible software.

Specifications

Temperature Sensor	
Operation range	-40° to 70°C (-40° to 158°F) in air; maximum sustained temperature of 50°C (122°F) in water
Accuracy	0.2°C over 0° to 50°C (0.36°F over 32° to 122°F), see Plot A
Resolution	0.02°C at 25°C (0.04°F at 77°F), see Plot A
Response time (90%)	5 minutes in water; 12 minutes in air moving 2 m/sec (typical)
Stability (drift)	0.1°C (0.18°F) per year
Logger	
Real-time clock	± 1 minute per month 0° to 50°C (32° to 122°F)
Battery	2/3 AA, 3.6 Volt Lithium, factory-replaceable ONLY
Battery life (typical use)	6 years with 1 minute or greater logging interval
Memory (non-volatile)	64K bytes memory (approx. 42,000 12-bit temperature measurements)
Weight	42 g (1.5 oz)
Dimensions	3.0 cm (1.19 in.) maximum diameter, 11.4 cm (4.5 in.) length; mounting hole 6.3 mm (0.25 inches) diameter
Wetted materials	Polypropylene case, EPDM o-rings, stainless steel retaining ring
Buoyancy (fresh water)	+13 g (0.5 oz.) in fresh water at 25°C (77°F); +17 g (0.6 oz.) with optional boot
Waterproof	To 120 m (400 ft.)
Shock/drop	1.5 m (5 ft.) drop at 0°C to 70°C (32°F to 150°F)
Logging interval	Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to HOBOware software manual.
Launch modes	Immediate start and delayed start
Offload modes	Offload while logging; stop and offload
Battery indication	Battery voltage can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.
NIST certificate	Available for additional charge
CE	The CE Marking identifies this product as complying with the relevant directives in the European Union (EU).



Plot A

Part #: MAN-U22-001, Doc #: 10366-D

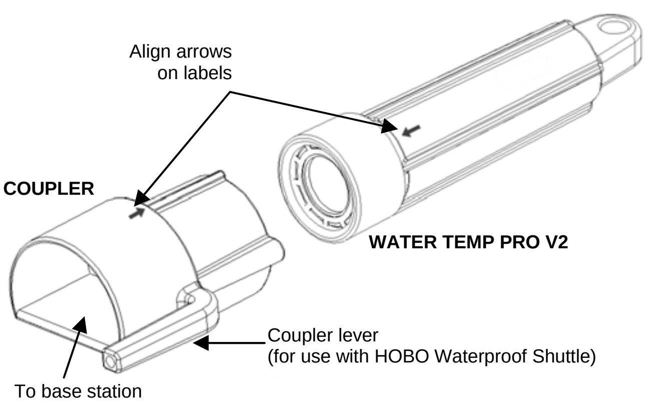
Accessories Available

Optional protective boot: Black (Part # BOOT-BLK) or White (Part # BOOT-WHT).

Connecting the Logger

The HOBO Water Temp Pro v2 requires a coupler (Part # COUPLER2-C) and USB Optic Base Station (Part # BASE-U-4) or HOBO Waterproof Shuttle (Part # U-DTW-1) to connect to the computer.

1. Install the logger software on your computer before proceeding.
2. Follow the instructions that came with your base station or shuttle to attach the base station or shuttle to a USB port on the computer.
3. Make sure the logger's communications window is clean and dry. (Use a clean, nonabrasive cloth, if necessary.) If the logger is wet, wipe off excess moisture.
4. Attach the coupler to the base station or shuttle, then insert the logger into the coupler with the arrow on the logger label aligned with the arrow on the coupler label.



5. If you are using the HOBO Waterproof Shuttle, briefly press the coupler lever to put the shuttle into base station mode.
6. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.
7. Use the logger software to launch the logger. You can check the logger's status, read out the logger while it continues to log, stop it manually with the software, or let it record data until the memory is full.

Refer to the software user's guide for complete details on launching, reading out, and viewing data from the logger, including multiple logging intervals.

Important: USB communications may not function properly at temperatures below 0°C (32°F) or above 50°C (122°F).

Note: The logger consumes significantly more power when it is "awake" and connected to a base station or shuttle. To conserve power, the logger will go into a low-power (sleep) mode if there has been no communication with your computer for 30 minutes. To wake up the logger, remove the logger from the coupler, wait a moment, then re-insert the logger.

Note: The first time you launch the logger, the deployment number will be greater than zero. Onset launches the loggers to test them prior to shipping.

Operation

A light (LED) in the communications window of the logger confirms logger operation. (In brightly lit areas, it may be necessary to shade the logger to see the LED blink.) The following table explains when the light blinks during logger operation:

When:	The light:
The logger is logging	Blinks once every one to four seconds (the shorter the logging interval, the faster the light blinks); blinks when logging a sample
The logger is awaiting a start because it was launched in Start At Interval or Delayed Start mode	Blinks once every eight seconds until logging begins

Sample and Event Logging

The logger can record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval (for example, temperature every minute). Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging.

The logger stores 64K of data, and can record over 42,000 12-bit temperature measurements.

Deploying and Protecting the Logger

- Depending on water conditions and desired measurement location, the logger should be appropriately weighted, secured, and protected.

  Some monitoring applications require precise placement of the temperature sensor, such as measuring the temperature of a flow at the bottom of a stream or river. Ensure that the logger is appropriately secured so that the temperature sensor is in the desired measurement location.

- **IMPORTANT**: The plastic case will become brittle at temperatures lower than -20°C. If the logger is deployed in a location where the temperature drops below -20°C, make sure the logger remains stationary and is not pulled on or struck. Return the logger to above -20°C before handling.
- The opening at the sensor end of the logger accepts 1/4 inch (6.35mm) diameter nylon cord or other strong cable. If wire is wrapped through the sensor end to secure the logger, make sure the wire loop is snug to the sensor end. Any slack in the loop may cause excessive wear.
- The logger is slightly positive buoyant so that it will float if it is inadvertently dropped in the water or breaks free from its mooring. You may want to mark or label the logger with contact information in case the logger is lost.
- Onset recommends an optional boot (Part # BOOT-BLK or BOOT-WHT) for protection against very cold temperatures (which can make the case brittle and prone to fracture), or repeated pounding and abrasion caused by turbulent flow. The boot slides over the logger, has a removable end cap, and is flexible enough to allow you to attach the coupler without removing the boot. To attach the base station, remove the end cap and firmly insert the logger until the boot folds back. Make sure the arrow on the logger label is aligned with the arrow on the coupler label.

  Although the boot does not cover the sensor end of the logger, the temperature response time (to 90% of final value) in water increases slightly from 5 to 8 minutes due to the increased mass.
- This logger should not be immersed for extended periods in any liquid other than fresh or salt water. To do so may void the warranty (refer to the Service and Support section). If you have any questions about chemical resistance, call Onset.
- Prolonged exposure to chlorinated water is not recommended.
- To clean the logger, rinse it in warm water. Use a mild dishwashing detergent if necessary. Do not use harsh chemicals, solvents, or abrasives, especially on the communications window.

Battery

The battery in the HOBO Water Temp Pro v2 is a 3.6 Volt lithium battery. The battery life of the logger should be about six years. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. To obtain a six-year battery life, a logging interval of one minute or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F). Frequent deployments with logging intervals of less than one minute, and continuous storage/operation at temperatures above 35°C, will result in significantly lower battery life. For example, continuous logging at a one-second logging interval will result in a battery life of approximately one month.

The logger can report and log its own battery voltage. If the battery falls below 3.1 V, the logger will record a “bad battery” event in the datafile. If the datafile contains “bad battery” events, or if logged battery voltage repeatedly falls below 3.3 V, the battery is failing and the logger should be returned to Onset for battery replacement.

To have your logger’s battery replaced, contact Onset or your place of purchase for return arrangements. Do not open the case or attempt to replace the battery yourself. There are no user-serviceable parts inside. If you open the case, the warranty will be voided, and the logger may no longer be waterproof.

WARNING: Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

Patent #: 6,826,664

HYPACK®

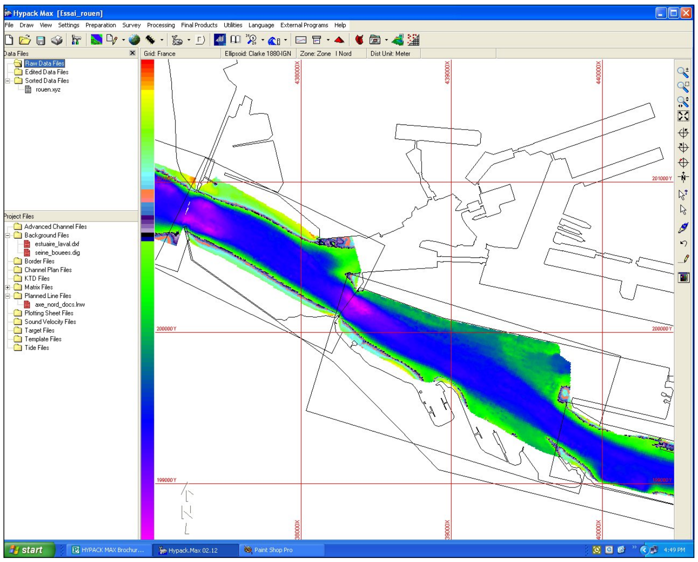
HYPACK

SOUNDING BETTER!

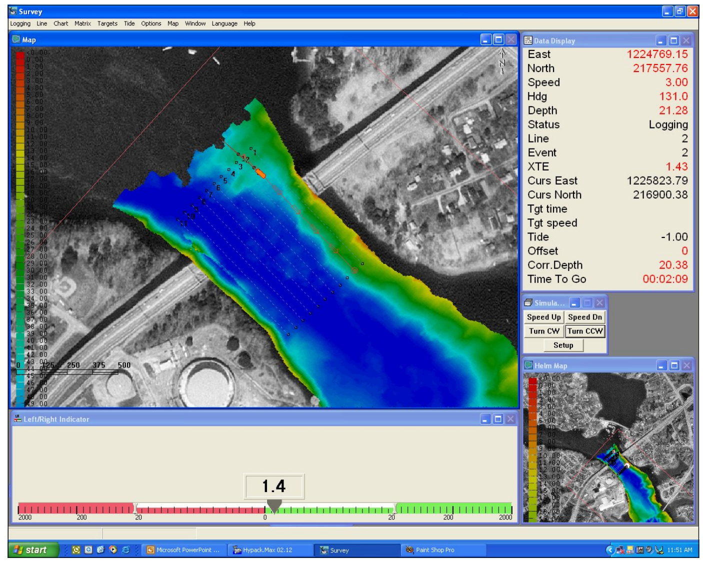
HYDROGRAPHIC SURVEY SOFTWARE

HYPACK®

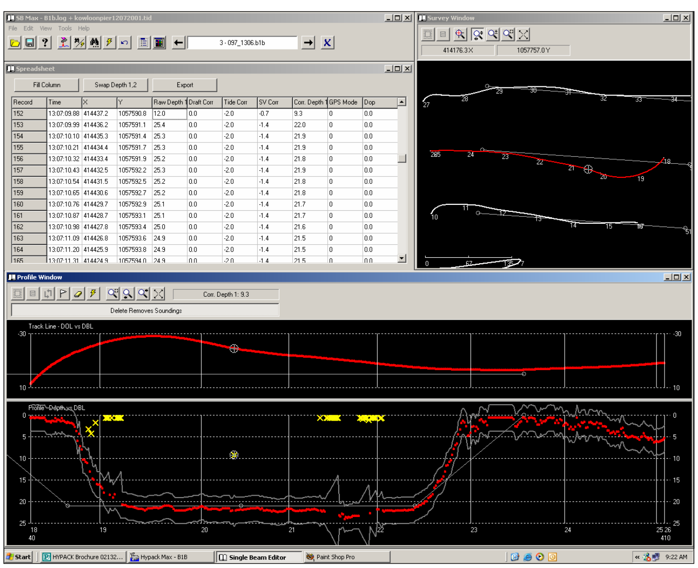
HYPACK® is one of the most widely used hydrographic surveying packages in the world, with over 3,000 users. It provides the surveyor with all of the tools needed to design their survey, collect data, process it, reduce it, and generate final products. Whether you are collecting hydrographic survey data or environmental data, or positioning your vessel in an engineering project, HYPACK® provides the tools needed to complete your job. With users spanning the range from small vessel surveys with just a GPS and single beam echosounder to large survey ships with networked sensors and systems, HYPACK® gives you the power needed to accomplish your task in a system your surveyors can master.



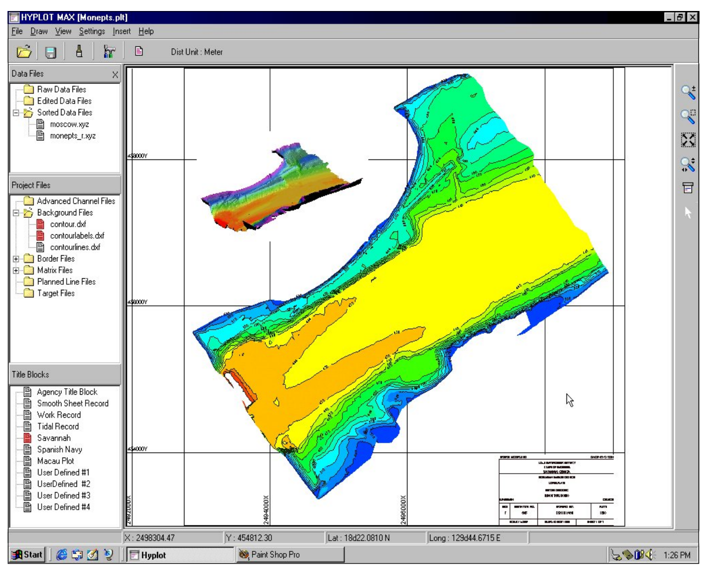
SURVEY DESIGN: HYPACK® allows you to create a 'Project' that contains all of your survey information for each job. You can easily define your geodetic basis, selecting from existing national grids or defining your own projection or local grid. HYPACK® also allows you to import background files in a variety of formats, including S-57, OrthoTif, ARCS, DXF, DGN, BSB and VPF. These files can be displayed while you create your planned lines, survey, edit and plot your results.



SURVEY: HYPACK® contains interface drivers to over 200 devices includings positioning systems, echosounders, heave-pitch-roll sensors, gyros and other types of equipment. SURVEY supports a single vessel or multiple vessels, along with towfish and ROVs. Data is logged with incredible precision (<1mSec). Survey data and windows can be broadcast over a network to any other computer or saved to a file using our Shared Memory Output routines.



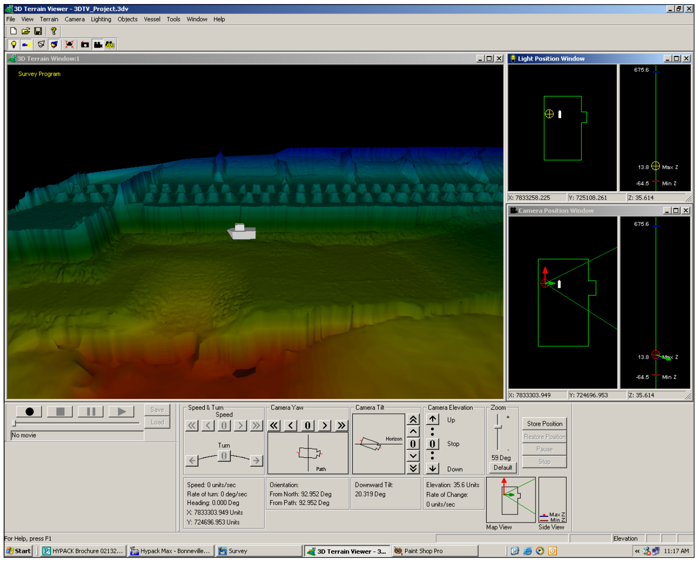
EDITING: The SINGLE BEAM EDITOR program is used to quickly review your survey data and to automatically and/or manually remove outliers. Sounding data is simultaneously displayed in plan, spreadsheet, and profile views with the channel design info drawn in the backgrounds. Routines developed by **HYPACK®** from collaboration with the U.S. Army Corps of Engineers to integrate water level corrections based on RTK GPS elevation info are a standard part of package.



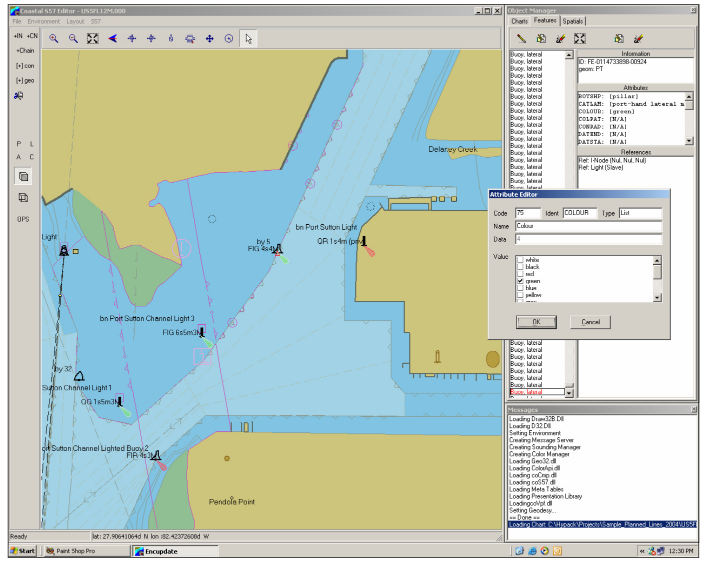
FINAL PRODUCTS: The ability to create the final products you need separates **HYPACK®** from the rest. The plotting program generates professional smooth sheets with soundings, grids, graphics and contours in a WYSIWYG display. The VOLUMES program is the de facto standard of the U.S. Army Corps of Engineers for the computation of quantities in dredging projects. TIN MODEL creates surface models that can be used for contouring, volume computations and surface visualization.

HYPACK®

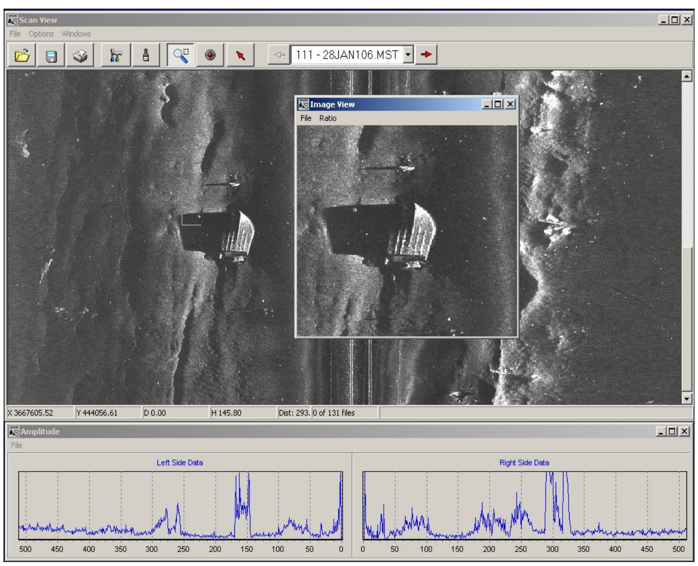
Support: An important factor in the purchase of any hydrographic survey system is the support provided to the end-user. **HYPACK®** prides itself on taking good care of our users. A trained, professional staff is on-call to answer your questions, develop custom device drivers or modify programs to meet your needs. **HYPACK®** training seminars are held annually in many countries to provide you with the latest information. We continue to update our training materials every year to make it easier for you to get the most out of our products. Our latest training material contains PowerPoint presentations with embedded AVI demonstrations on over 100 topics. Our bi-monthly newsletter, 'Sounding Better' is published on our web site (www.hypack.com) and contains technical articles on how to get the most out of your package.



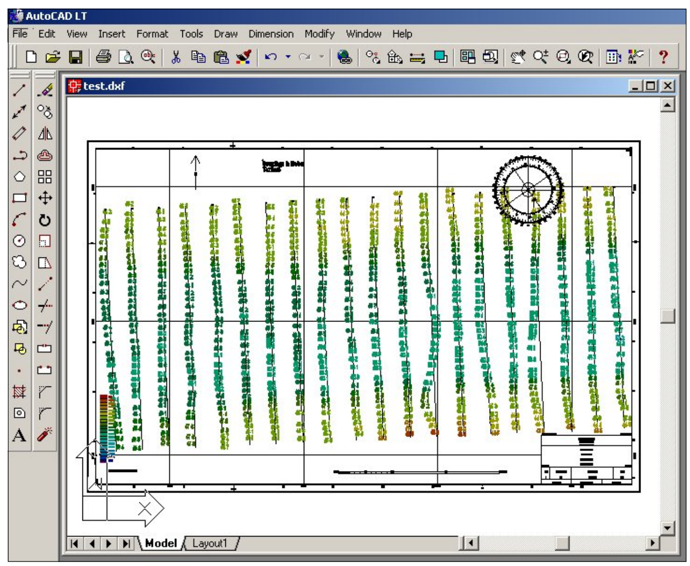
DATA VISUALIZATION: The TIN MODEL and 3D TERRAIN VIEWER (3DTV) programs of **HYPACK®** provide fantastic tools to view and present your data. 3DTV allows you to fly a 'camera' across your edited XYZ surface and display the results or save them to a AVI file for distribution to your clients. 3DTV also allows you to position the camera relative to the actual vessel position, showing the vessel in real time against the bottom surface.



ENCEdit is a new **HYPACK®** module that allows you to create, modify and verify ENC data in S-57 format. ENCEdit provides you with tools to re-attribute, create, move or delete existing features. You can also create new features by manually entering coordinates, by importing data from DXF/DGN, or by transferring targets in real time from SURVEY directly into ENCEdit.



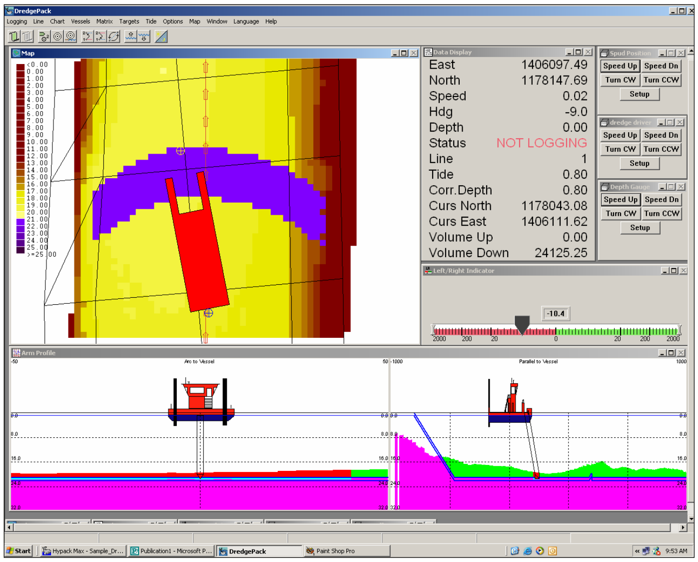
Side Scan Sonar (SSS) Support: HYPACK® provides support of SSS systems in its basic package. All analog and several digital side scan systems can be utilized with the SIDE SCAN SURVEY program. Users can display the real time data and perform targeting in real time or post-processing. A program that generates side scan mosaics in GeoTIF format allows you to plot your results in **HYPACK®** or export them to your GIS.



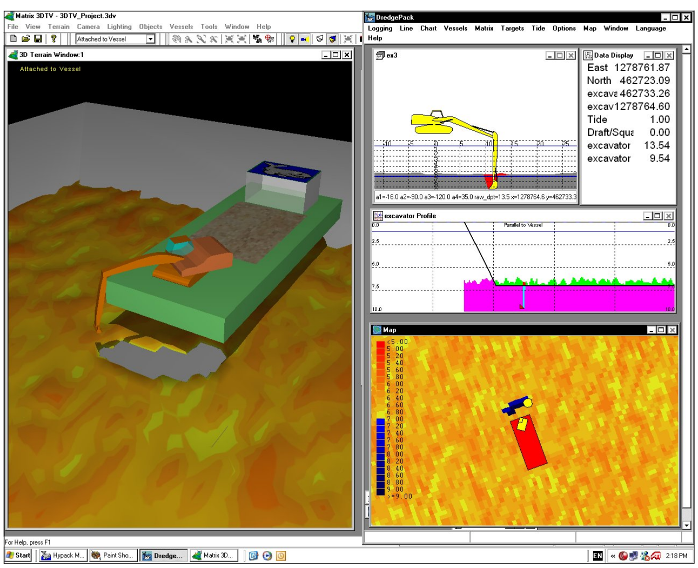
Export to CAD: Many of our users are interested in exporting their survey data into their CAD/GIS package. **HYPACK®** has several tools to import/export via DXF/DGN. The EXPORT TO CAD program takes all of the our files and converts them to DXF and DGN. The plotting sheets and sectional plots can also be exported directly to DXF. Users can create planned lines in their CAD/GIS program and import them into **HYPACK®**.

DREDGEPACK®

DREDGEPACK® is a specially modified version of **HYPACK®** used for providing precise digging information on dredges. It allows you to see exactly where you are digging, how deeply you are digging and how deeply you need to dig. With the ADVANCED CHANNEL DESIGN program, you can create complex dredging plans. Real time cross sections are provided to show you the design profile, the depth of the cutting tool and the material that has to be removed.

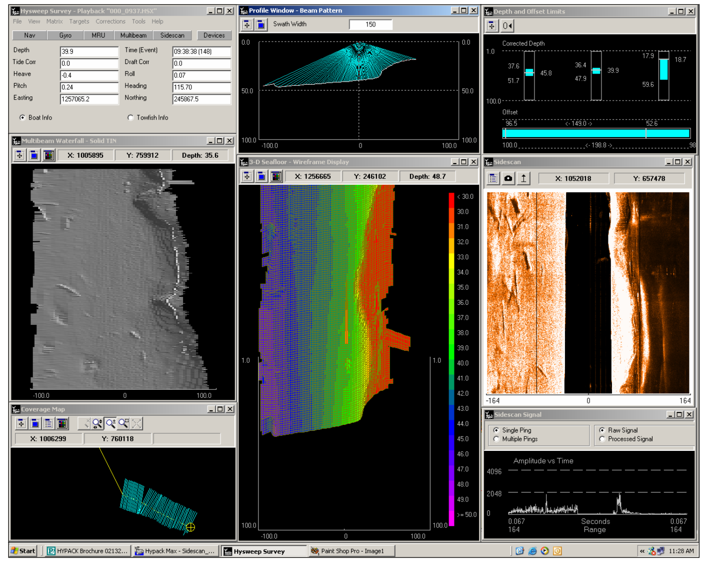


DREDGEPACK® runs on cutter suction, hopper, excavator and bucket-style dredges. It can store a history of the dredge's position, draft, digging tool depth and digging status in order to meet reporting requirements. DREDGEPACK® has been designed to run with a minimum of user intervention. Make sure you are maximizing your dredge's efficiency with DREDGEPACK®

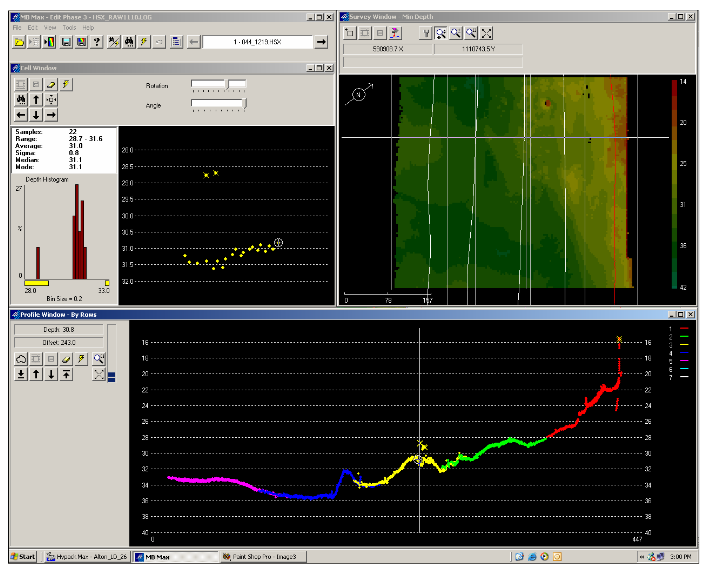


HYSWEEP®

HYSWEEP® is an optional module that integrates the collection and processing of multibeam and multiple transducer sonar systems into **HYPACK®**. Time and again, surveyors switch to HYSWEEP® due to the powerful tools and the ease-of-use of the package. Survey data collected in **HYSWEEP®** is fully integrated with the final products of **HYPACK®**. More surveyors use **HYSWEEP®** for multibeam data collection and processing than any other multibeam software package.



HYSWEEP® SURVEY: The data collection program of **HYSWEEP®** runs simultaneously with the SURVEY program of **HYPACK®**. It provides real time display, QC functions and data logging for most commercially available multibeam systems, including those from Atlas, Odom, Reson, Sea Beam and Simrad. A coverage map lets you examine the bottom coverage in real time, ensuring that you have 100% or 200% coverage before leaving the area.



MULTIBEAM EDITING: Multibeam data editing, sonar alignment calibration and system performance testing are all provided in the powerful MULTIBEAM EDITOR of **HYSWEEP®**. The program performs automatic or manual filtering, using geometric and statistical methods. It also contains the Performance Test that measures the overall performance of your system versus beam angle as required by USACE. **HYSWEEP®** can also use water level corrections created from RTK GPS elevations.

HYPACK
SOUNDING BETTER!

HYPACK, Inc.

56 Bradley St.
Middletown, CT 06457
Phone: 860-635-1500
Web: www.hypack.com
Sales: sales@hypack.com

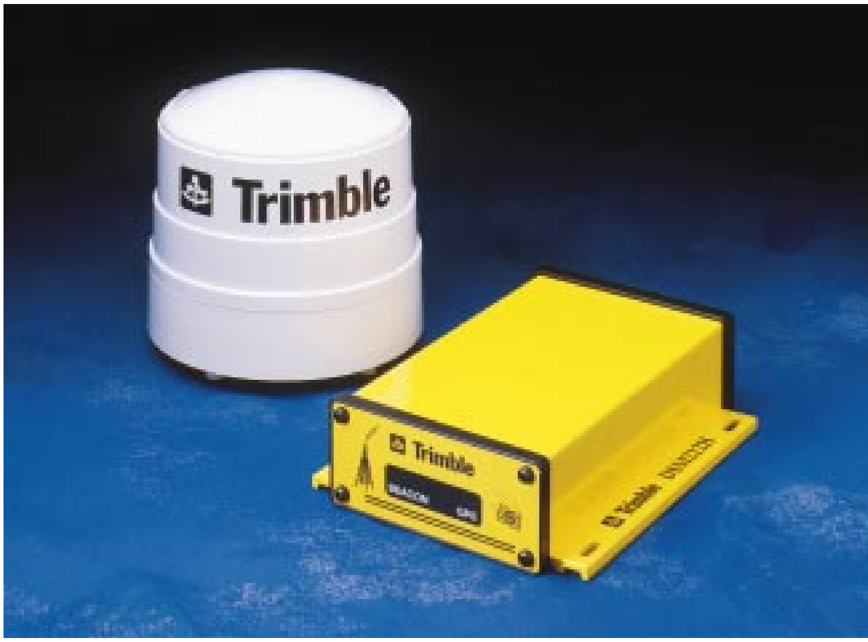
DSM12/212 Product Family

Integrated, cost-effective and reliable sub-meter positioning for your marine application

Key features and benefits

- Compact
- Easy Installation
- High Position Output Rate With Low Latency
- Easy To Use & Setup
- Low Power Consumption
- Increased Jamming Resistance
- Optional Everest Multipath Rejection
- Isolated Power Supply

The DSM12/212 Product Family targets marine professionals in need of sub-meter positioning during applications such as precise positioning, dredging, hydrographic surveying, high speed vessel positioning, and many more.



Integrated GPS and dual-channel MSK beacon receiver, DSM212H

Complete System Solution

The product family includes three mobile receivers and one reference station receiver:

- DSM12™ – DGPS receiver
- DSM212L™ – Integrated GPS/MSK receiver, 1Hz output
- DSM212H™ – Integrated GPS/MSK receiver, 10Hz output
- DSM12RS™ – DGPS Reference Station receiver

Cost Effective

The family of 12 channel GPS receivers use Trimble's latest technology to achieve sub-meter positioning accuracy. These receivers maintain their high performance in environments where GPS availability and accuracy are sometimes an issue. Everest™ technology improves results in high multipath environments and locations where other radio frequencies could jam the GPS signals such as harbors, oil platforms, and construction sites. The DSM12, DSM212L & DSM212H can all accept RTCM SC-104 differential corrections from an external source through a serial interface. The DSM212L & DSM212H also include an integrated dual-channel low-noise MSK beacon receiver.

The MSK beacon receiver provides superior weak-signal reception performance, allowing differential corrections to be received at long distances from the reference station and during challenging weather conditions. The dual-channel capability allows for intelligent and seamless switching between beacons.

Superior Integration

The DSM12, DSM212L and DSM212H are easy to connect with other onboard equipment such as integrated bridge systems, radars, autopilots and plotters. Through one of the two serial ports, these receivers output standard NMEA-0183 messages, including position, velocity and status information. The DSM12 & DSM212L receivers output position reports once a second.

The DSM212H outputs position reports at an increased output rate of 10 Hz, with a maximum latency of 0.1 second. The second serial port is for setup, control and data output using Trimble Standard Interface Protocol (TSIP). For easy setup, a Windows-based Trimble Navigation software, TSIP Talker™ is included. The receivers also feature a 1 PPS output available on either serial port and offer a differential speed accuracy of better than 0.1 Knot.

Reference Station

The DSM12RS is a cost-effective solution for providing high quality DGPS corrections. The corrections are generated in the standard RTCM SC-104 format for broadcast.

DSM12/212 Product Family

Integrated, cost-effective and reliable sub-meter positioning for your marine application

STANDARD FEATURES

Standard Configuration

- 12-channel GPS receiver
- Integrated GPS and dual channel MSK beacon receiver (DSM212L & DSM212H)
- External RTCM SC-104 input
- Isolated power supply
- Positioning based on carrier-phase filtered L1 pseudo-ranges
- Two programmable RS-232 serial ports:
  - NMEA-0183 output or RTCM SC-104 output
  - RTCM SC-104 input
  - TSIP Input & Output
- 1PPS output
- Windows Configuration software
- DSM12/212 Operation manual
- Compact L1 GPS antenna (DSM12)
- Compact L1 Geodetic GPS antenna with removable groundplane (DSM12RS)
- Combined L1 GPS and MSK H-field loop antenna (DSM212L & DSM212H)
- 15 meter RG58 antenna cable (DSM12, DSM212L, & DSM212H)
- 30 meter RG213 antenna cable (DSM12RS)
- Power/data cable
- 12Pin to Split I/O Cable (DSM12)
- 12Pin to Split RTCM Cable (DSM12RS)
- 12Pin to Data Cable (DSM212L & DSM212H)

PHYSICAL CHARACTERISTICS

Receiver

Size:	14.5cmW x 5.1cmH x 19.5cmD (5.7"W x 2.0"H x 7.7"D)
Weight:	0.76kg (1.68 lb.)
Power:	5W (max.), 10 to 32 VDC
Operating temp:	-30°C to +65°C
Storage temp:	-40°C to +85°C
Humidity:	100% condensing, unit fully sealed

Combined Antenna (DSM212L & DSM212H)

Size:	15cmD x 15.5cmH (5.8"D X 6.0"H)
Weight:	4.9kg (2.2 lb.)
Operating temp:	-40°C to +65°C
Humidity:	100%-fully sealed

Compact Dome Antenna (DSM12)

Size:	15.4cmD x 8.9cmH (6"D X 3.5"H)
Weight:	0.29kg (0.645 lb.)
Operating temp:	-40°C to +70°C
Humidity:	100%-fully sealed

Compact L1 Geodetic Antenna (DSM12RS)

Size:	48cmD x 9cmH (19"D X 3.5"H)
Weight:	2.6kg (5.7 lb.)
Operating temp:	-40°C to +65°C
Humidity:	100% - fully sealed

PERFORMANCE CHARACTERISTICS

GPS Receiver

General:	12-channel, parallel tracking, L1 C/A code with carrier phase filtered measurements and multi-bit digitizer
Output rate:	1 Hz standard (DSM12, DSM12RS, & DSM212L) 10 Hz standard (DSM212H)
Differential speed accuracy:	0.1 kn (0.1 MPH, 0.16 km/h, 5.6cm/s)*
Differential position accuracy:	Less than 1 meter horizontal RMS* (At least 5 satellites, PDOP <4 and RTCM SC-104 standard format broadcast from a Trimble DSM12RS or equivalent reference station.)
Time to first fix:	<30 seconds, typical
NMEA messages:	ALM, GGA**, GLL, GSA, GSV, VTG**, ZDA, RMC, MSS **Default messages

MSK beacon Dual-channel Receiver

Frequency range:	283.5 KHz to 325.0 KHz
Channel spacing:	500 Hz
MSK modulation:	50, 100 & 200 bits/second
Signal strength:	10 µV/meter minimum @ 100BPS
Dynamic range:	100 dB
Channel selectivity:	70 dB >500 Hz offset
Frequency offset:	17 ppm maximum
3rd order intercept:	+15 dBm @ RF input (min. AGC setting)
Beacon acquisition time:	<5 sec, typical

OPTIONS

- High Output Rate
- Everest Multipath Rejection
- Reference Station
- Carrier Phase Output
- Extended hardware warranty
- Firmware update service

*To achieve differential speed and position, the unit must be operating within the broadcast area of a reference station conforming to the International Association of Lighthouse Authorities Standards. All non-differential GPS receivers are subject to degradation of position and velocity accuracy under U.S. Department of Defense-imposed Selective Availability (S/A). Positions may be degraded up to 100 meters 2D RMS.

Trimble follows a policy of continuous product improvement. Specifications are thus subject to change without notice.

Trimble
THE GPS SOLUTION

Trimble Navigation Limited
Corporate Headquarters
645 North Mary Avenue
Sunnyvale, CA 94086
+1-408-481-8000
+1-408-481-2000 Fax
www.trimble.com

Trimble Navigation Europe Limited
Trimble House,
Meridian Office Park
Osborne Way
Hook, Hampshire RG27 9HX U.K.
+44 1256-760-150
+44 1256-760-148 Fax

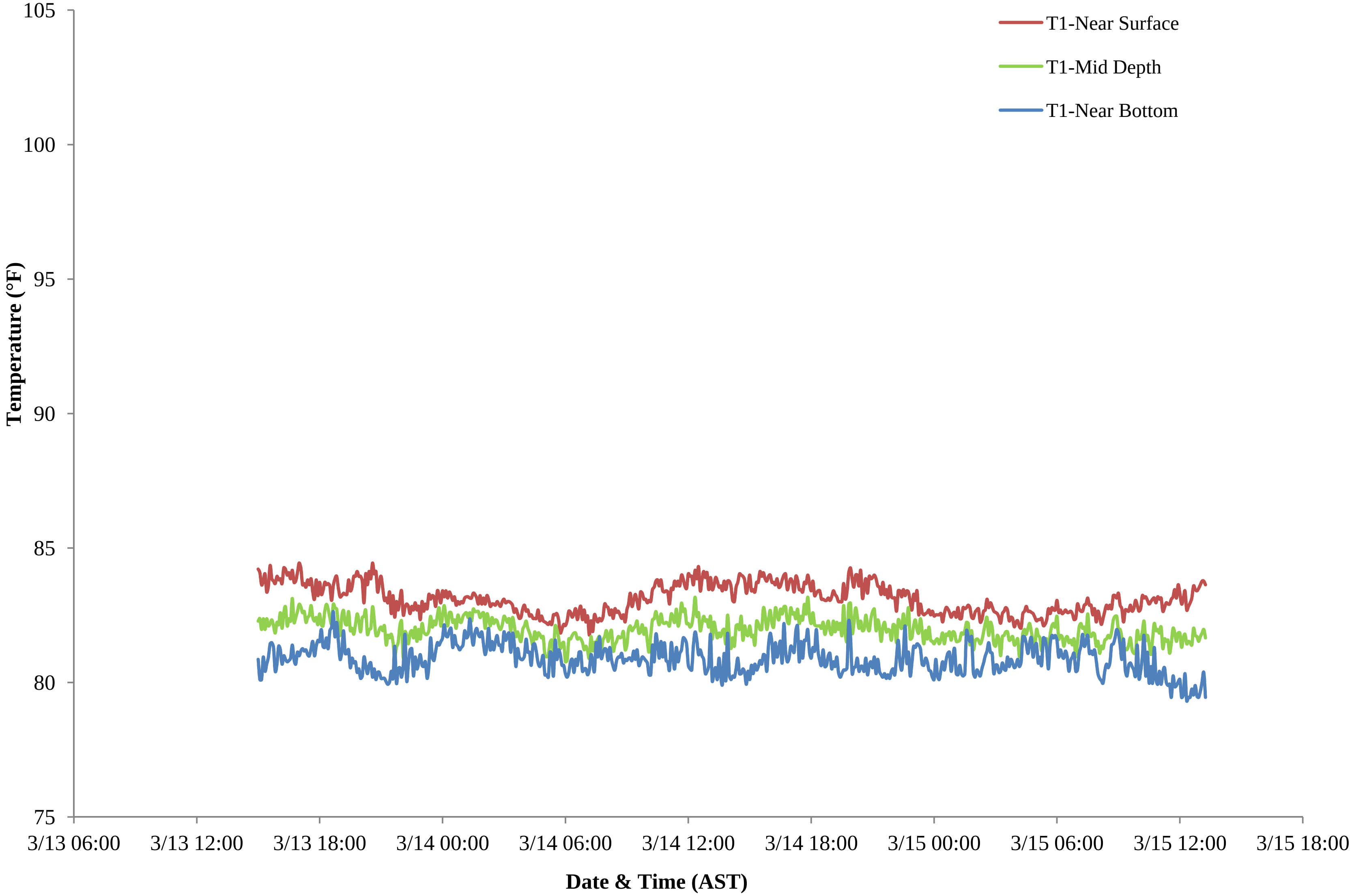
APPENDIX 2

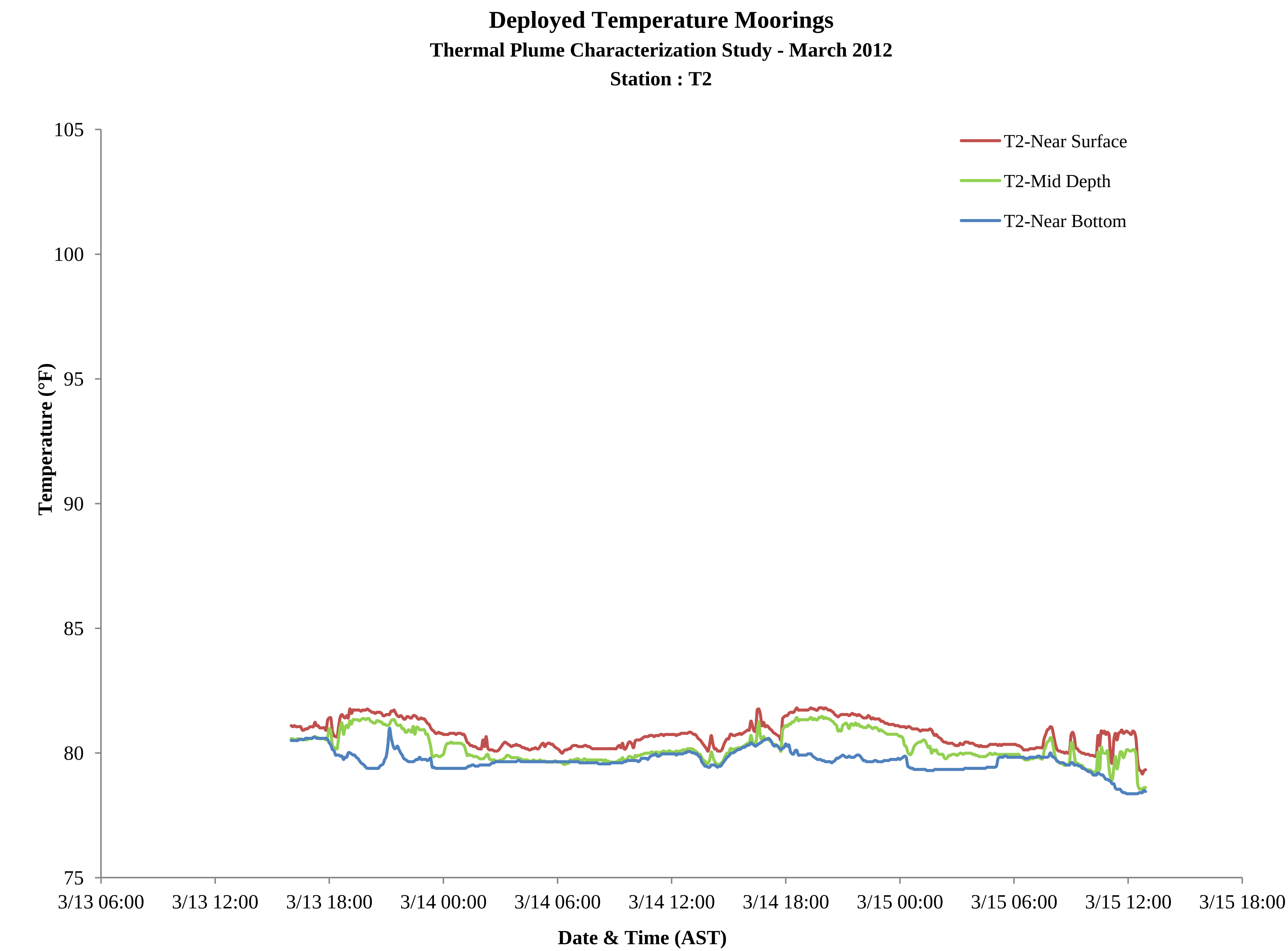
IN SITU TEMPERATURE TIME SERIES PLOTS

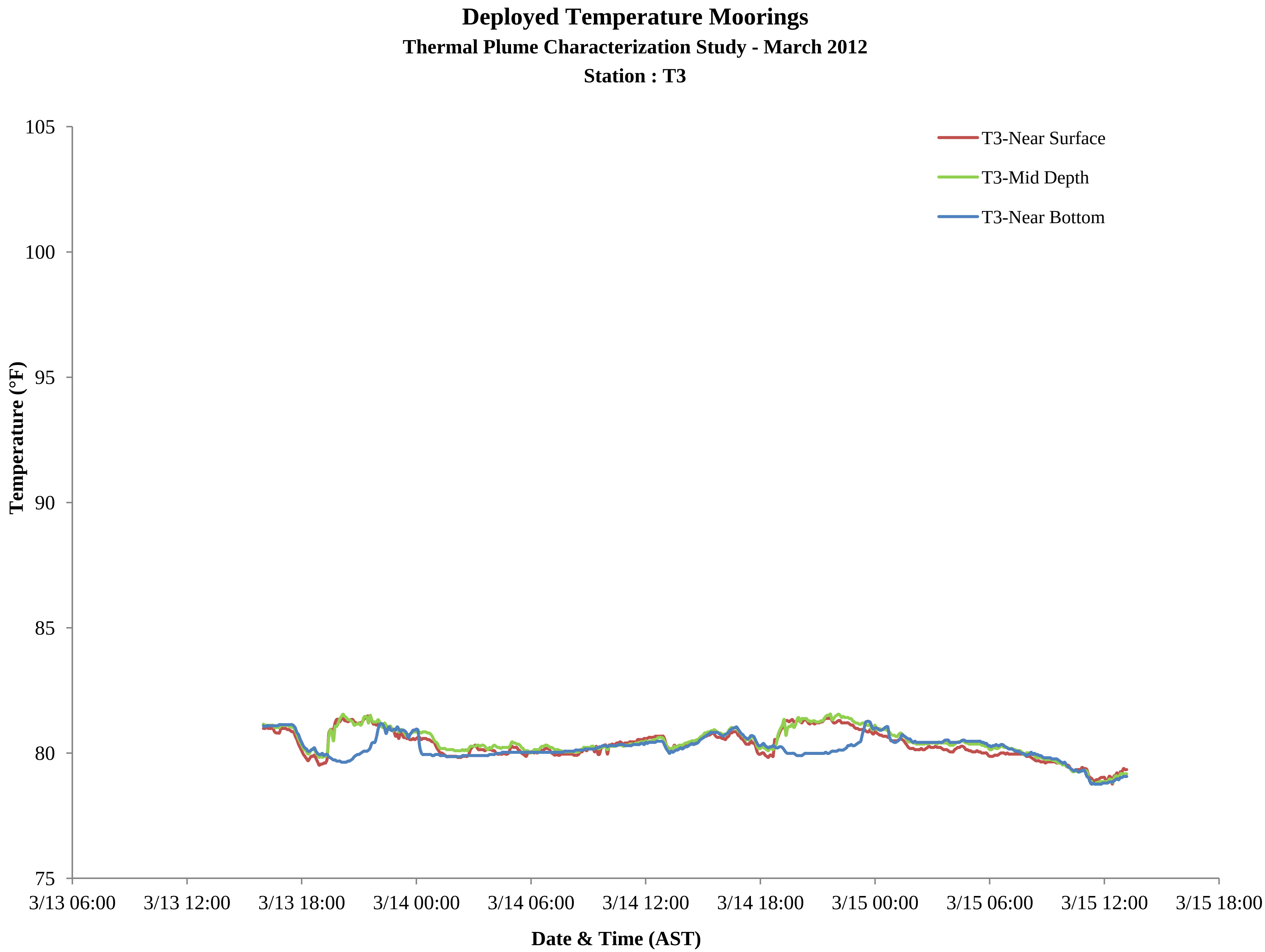
Deployed Temperature Moorings

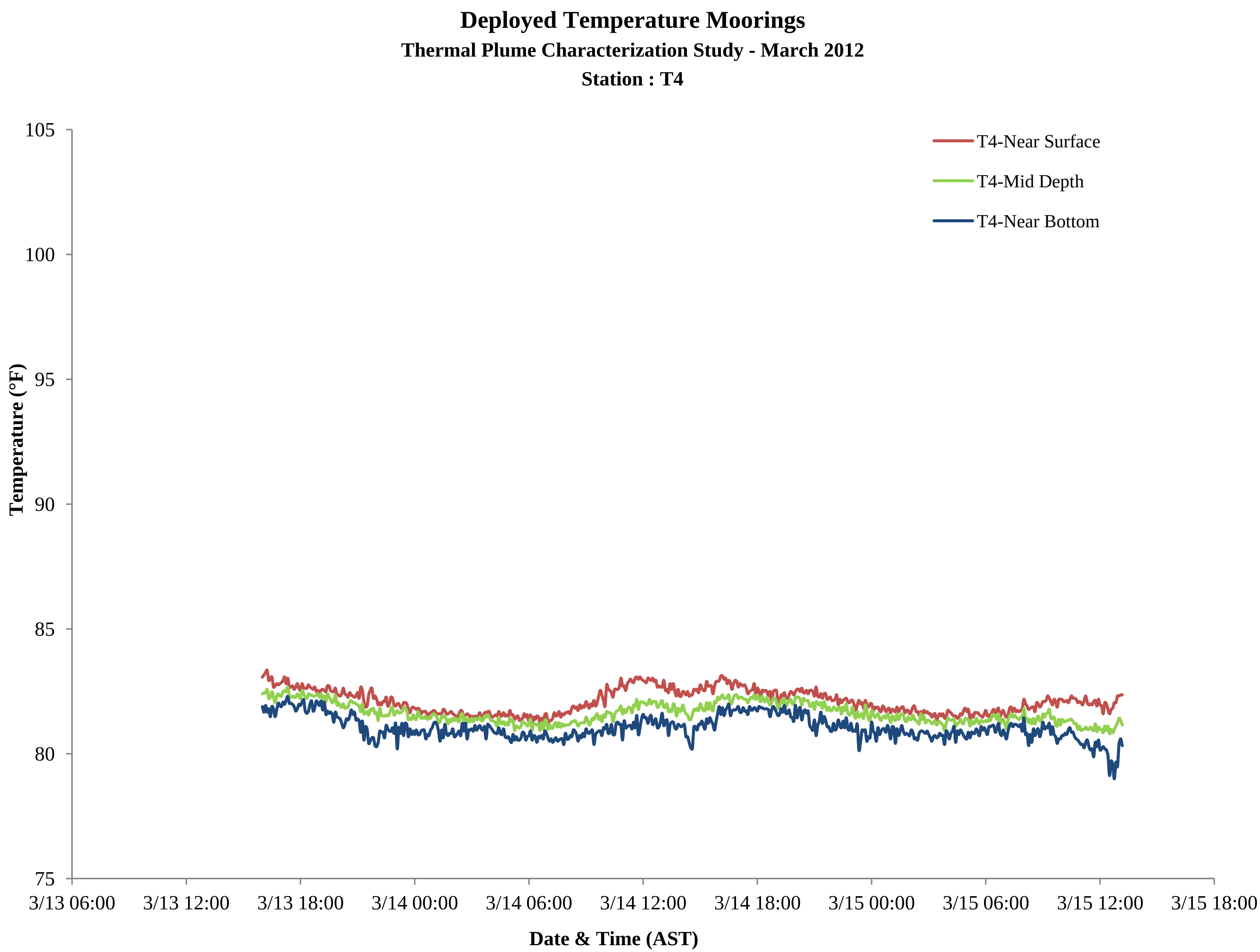
Thermal Plume Characterization Study - March 2012

Station : T1




Deployed Temperature Moorings
Thermal Plume Characterization Study - March 2012
Station : T2
T2-Near Surface
T2-Mid Depth
T2-Near Bottom
105
100
95
90
85
80
75
Temperature (°F)
3/13 06:00
3/13 12:00
3/13 18:00
3/14 00:00
3/14 06:00
3/14 12:00
3/14 18:00
3/15 00:00
3/15 06:00
3/15 12:00
3/15 18:00
Date & Time (AST)

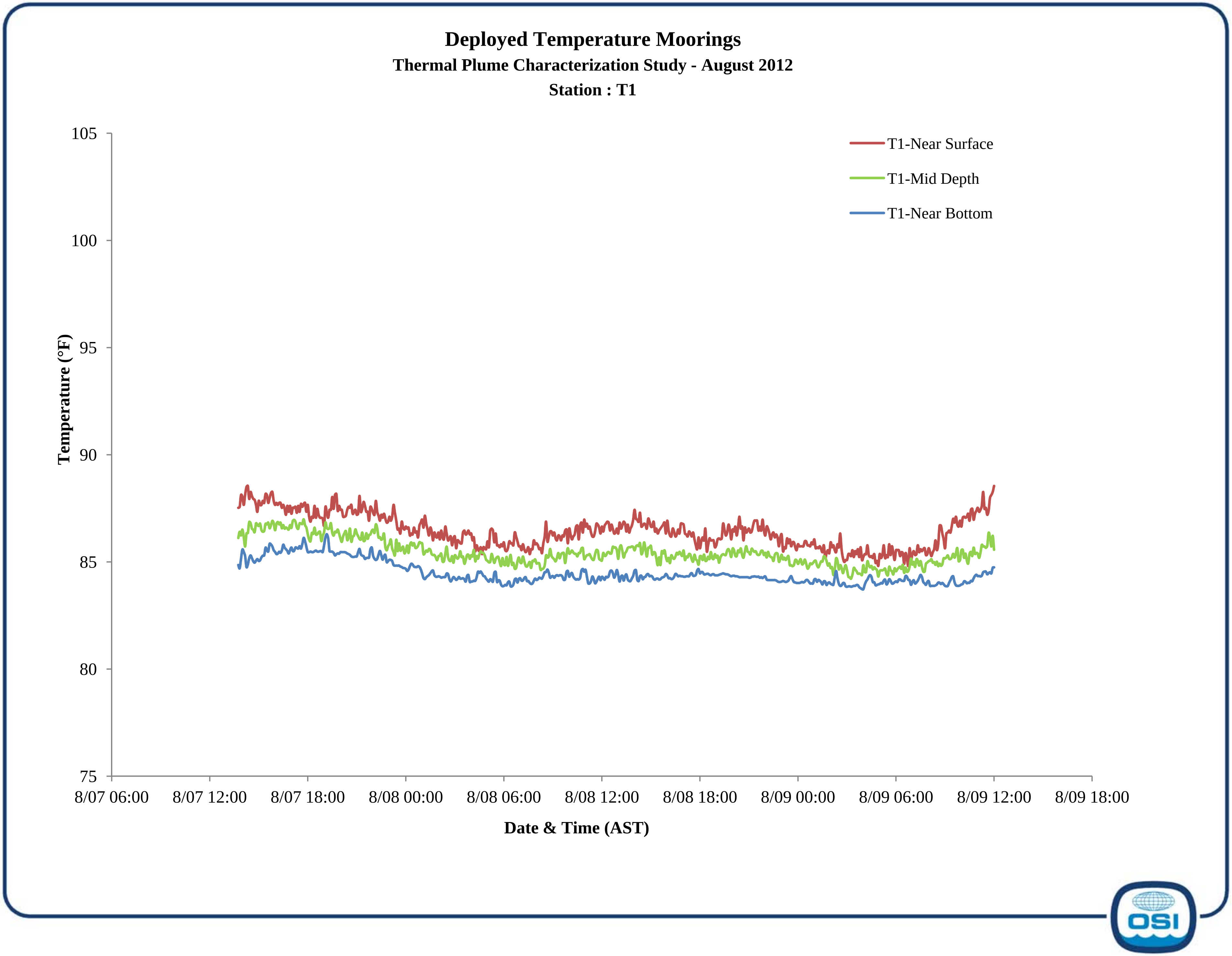

Deployed Temperature Moorings
Thermal Plume Characterization Study - March 2012
Station : T3
T3-Near Surface
T3-Mid Depth
T3-Near Bottom
Temperature (°F)
105
100
95
90
85
80
75
3/13 06:00
3/13 12:00
3/13 18:00
3/14 00:00
3/14 06:00
3/14 12:00
3/14 18:00
3/15 00:00
3/15 06:00
3/15 12:00
3/15 18:00
Date & Time (AST)
OSI


Deployed Temperature Moorings
Thermal Plume Characterization Study - March 2012
Station : T4
Temperature (°F)
105
100
95
90
85
80
75
T4-Near Surface
T4-Mid Depth
T4-Near Bottom
3/13 06:00
3/13 12:00
3/13 18:00
3/14 00:00
3/14 06:00
3/14 12:00
3/14 18:00
3/15 00:00
3/15 06:00
3/15 12:00
3/15 18:00
Date & Time (AST)
OSI

Deployed Temperature Moorings

Thermal Plume Characterization Study - March 2012

Station : T5

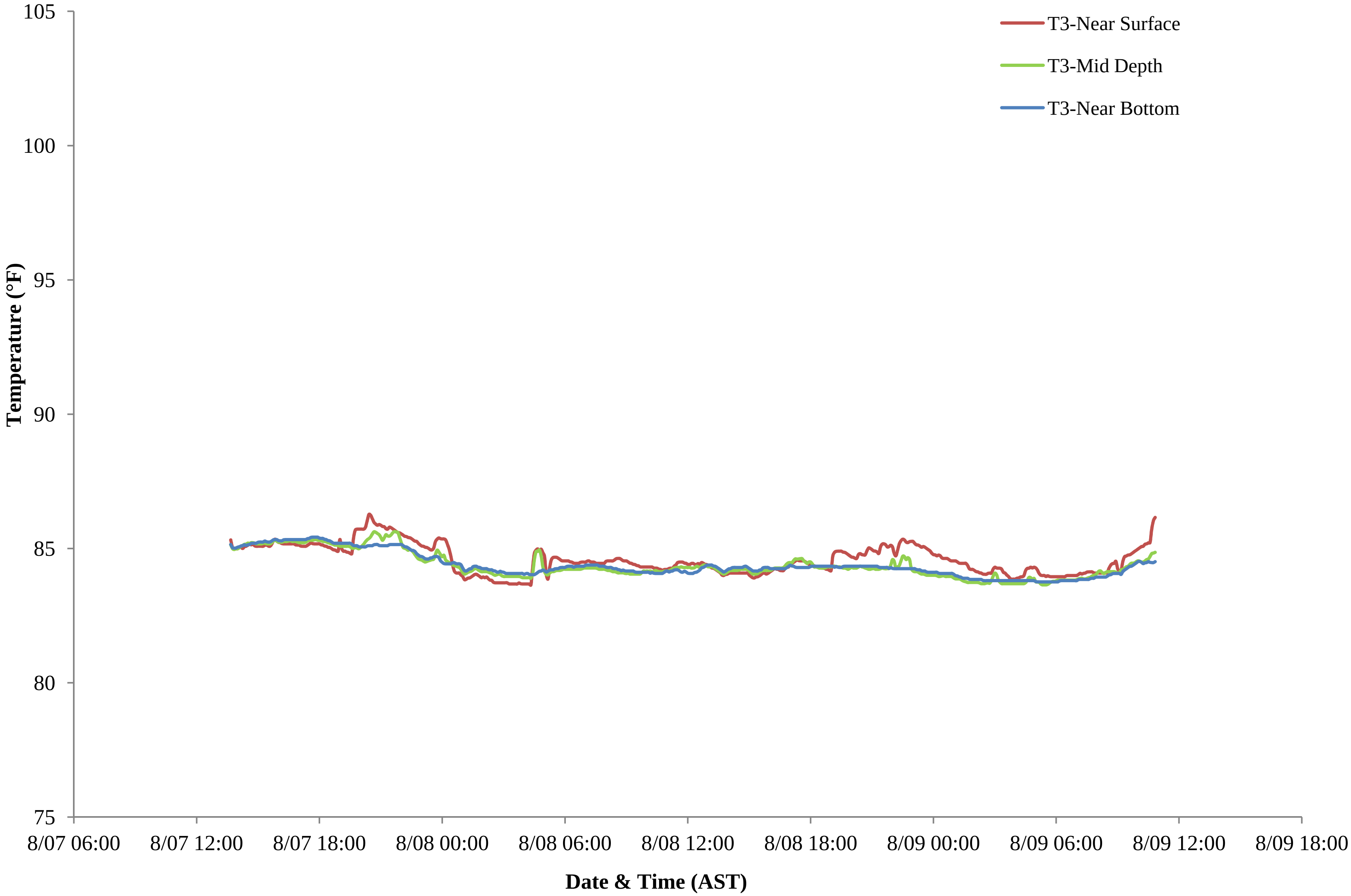

Deployed Temperature Moorings
Thermal Plume Characterization Study - August 2012
Station : T1
T1-Near Surface
T1-Mid Depth
T1-Near Bottom
Temperature (°F)
105
100
95
90
85
80
75
8/07 06:00
8/07 12:00
8/07 18:00
8/08 00:00
8/08 06:00
8/08 12:00
8/08 18:00
8/09 00:00
8/09 06:00
8/09 12:00
8/09 18:00
Date & Time (AST)
OSI


Deployed Temperature Moorings
Thermal Plume Characterization Study - August 2012
Station : T2
Temperature (°F)
105
100
95
90
85
80
75
8/07 06:00
8/07 12:00
8/07 18:00
8/08 00:00
8/08 06:00
8/08 12:00
8/08 18:00
8/09 00:00
8/09 06:00
8/09 12:00
8/09 18:00
Date & Time (AST)
T2-Near Surface
T2-Mid Depth
T2-Near Bottom

Deployed Temperature Moorings

Thermal Plume Characterization Study - August 2012

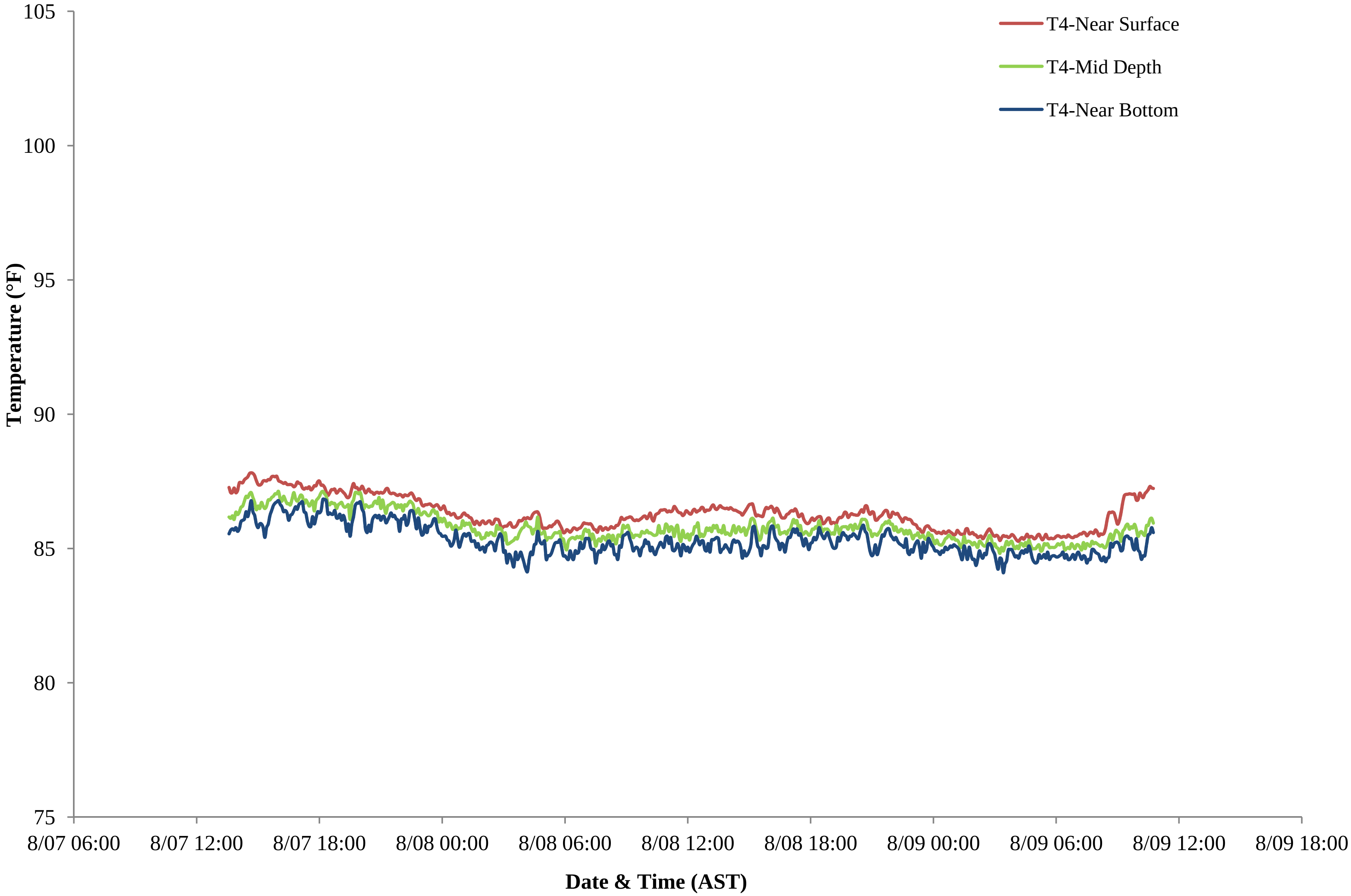
Station : T3

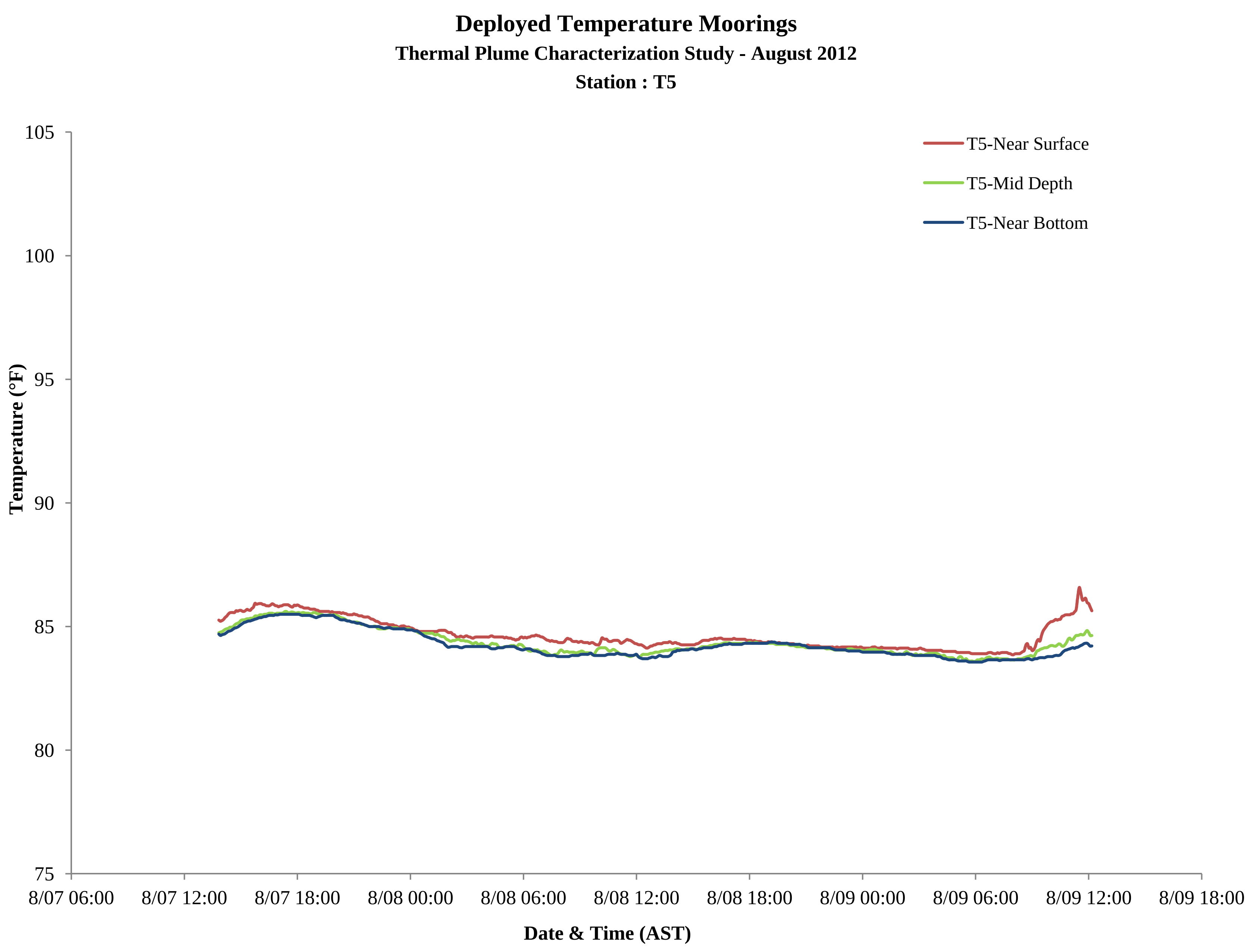


Deployed Temperature Moorings

Thermal Plume Characterization Study - August 2012

Station : T4

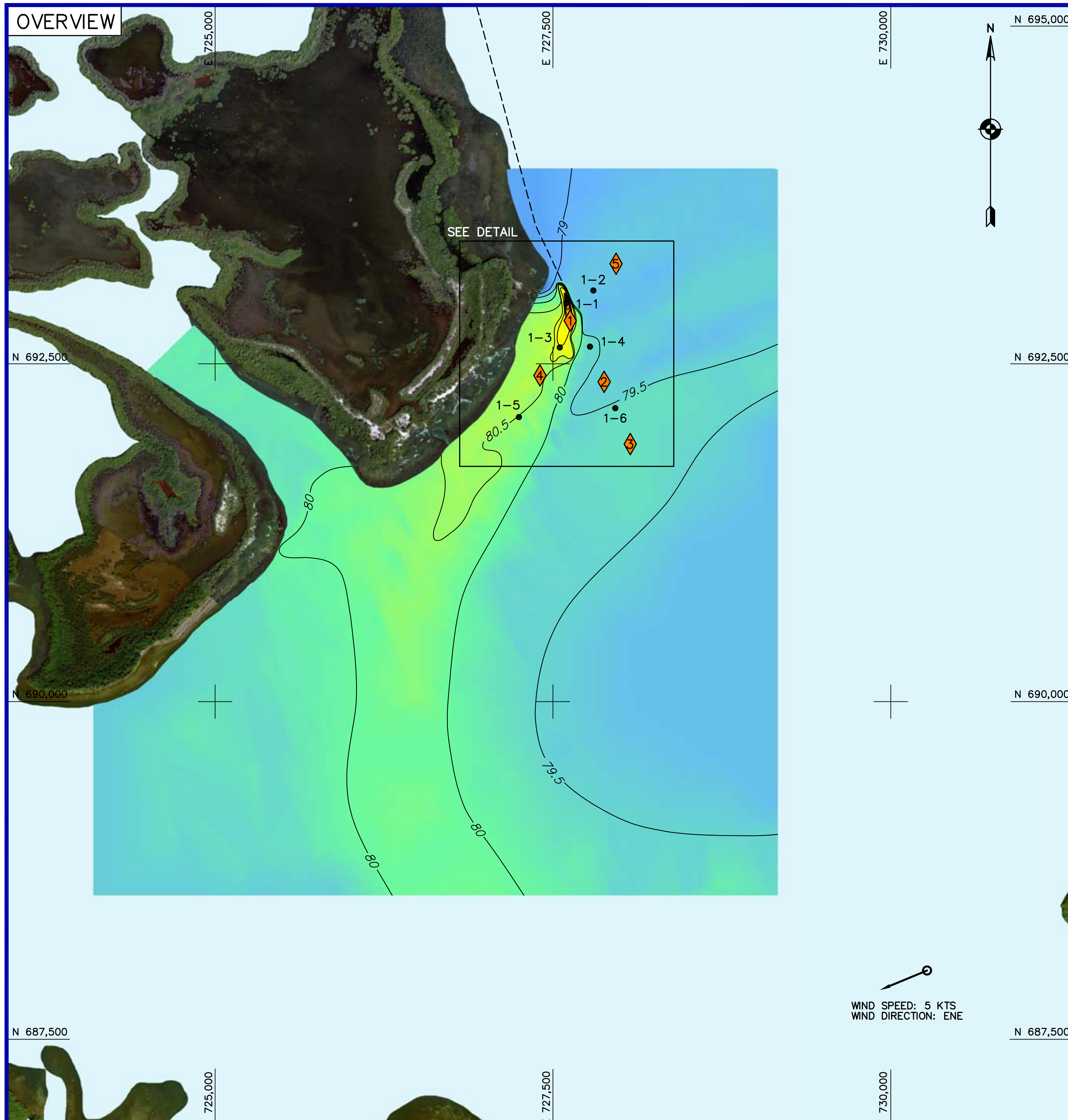


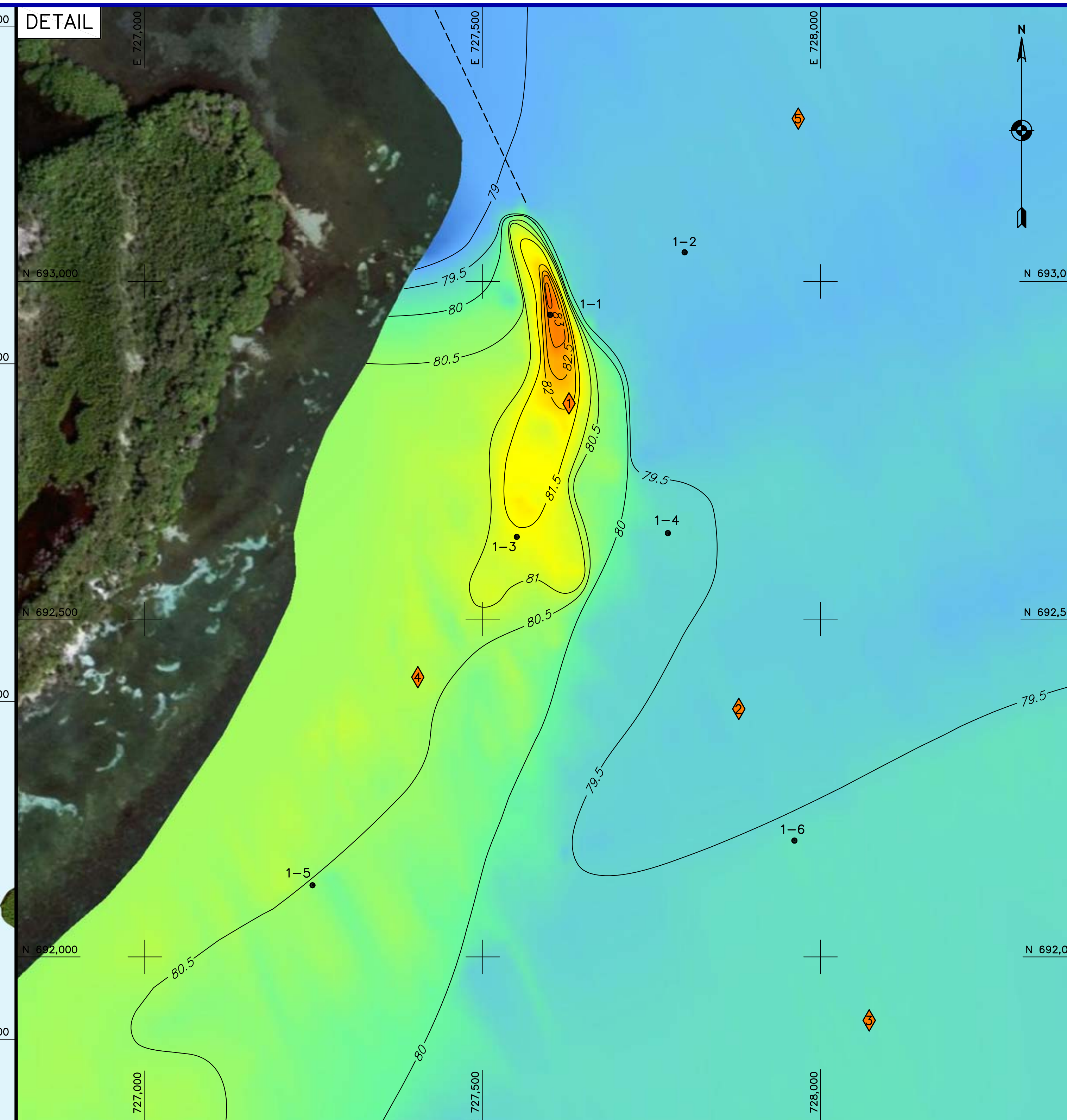


Deployed Temperature Moorings
Thermal Plume Characterization Study - August 2012
Station : T5
Temperature (°F)
105
100
95
90
85
80
75
8/07 06:00
8/07 12:00
8/07 18:00
8/08 00:00
8/08 06:00
8/08 12:00
8/08 18:00
8/09 00:00
8/09 06:00
8/09 12:00
8/09 18:00
Date & Time (AST)
T5-Near Surface
T5-Mid Depth
T5-Near Bottom

APPENDIX 3

REAL-TIME SURVEY TEMPERATURE PLUME DRAWINGS





LEGEND:

1-1 CTD CAST

TEMPERATURE MOORING

—80— TEMPERATURE CONTOUR °F

– – – DISCHARGE PIPE

TEMPERATURE °F

77 79 81 83 85 87

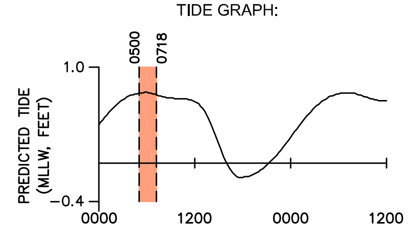
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:

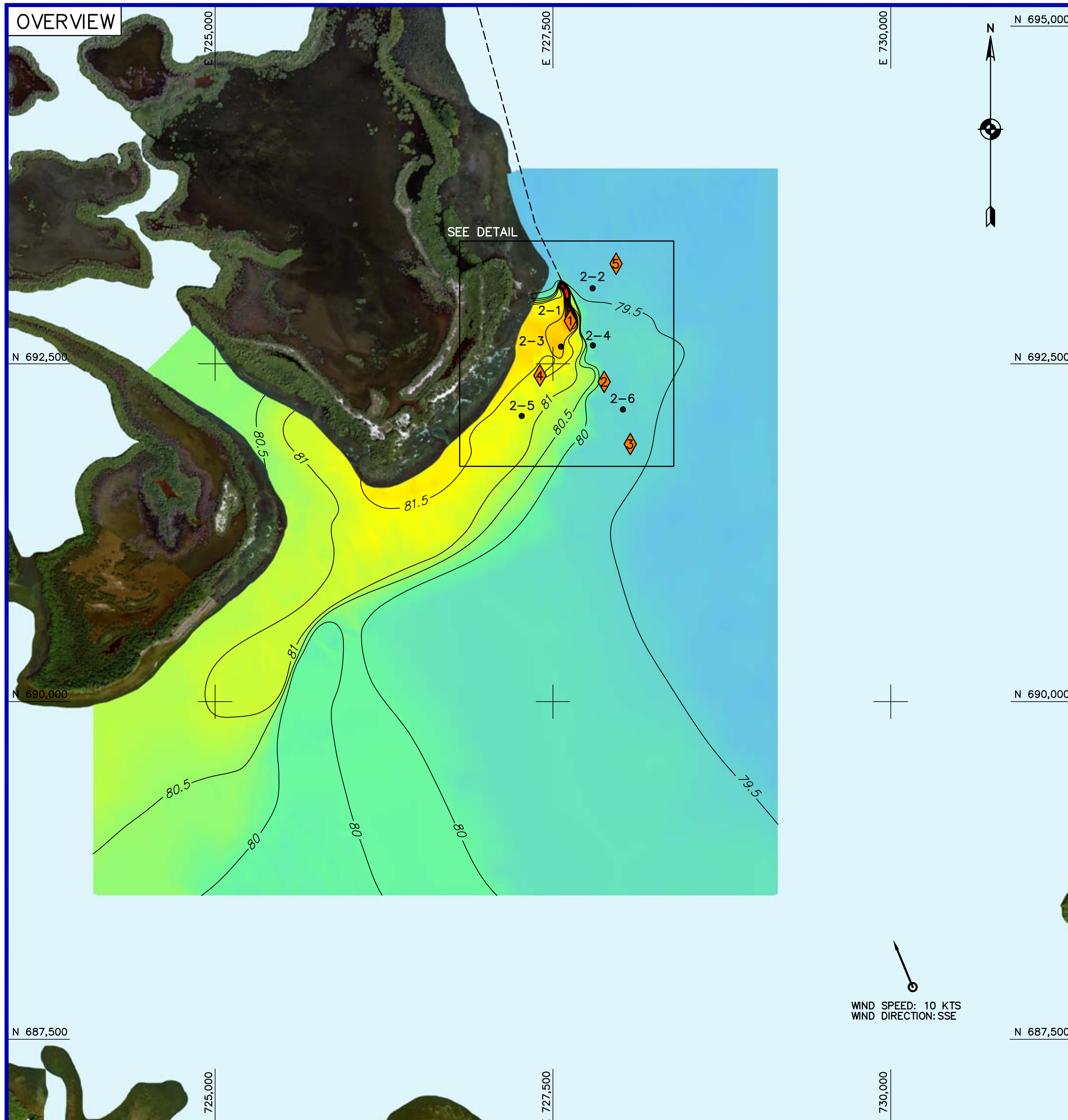


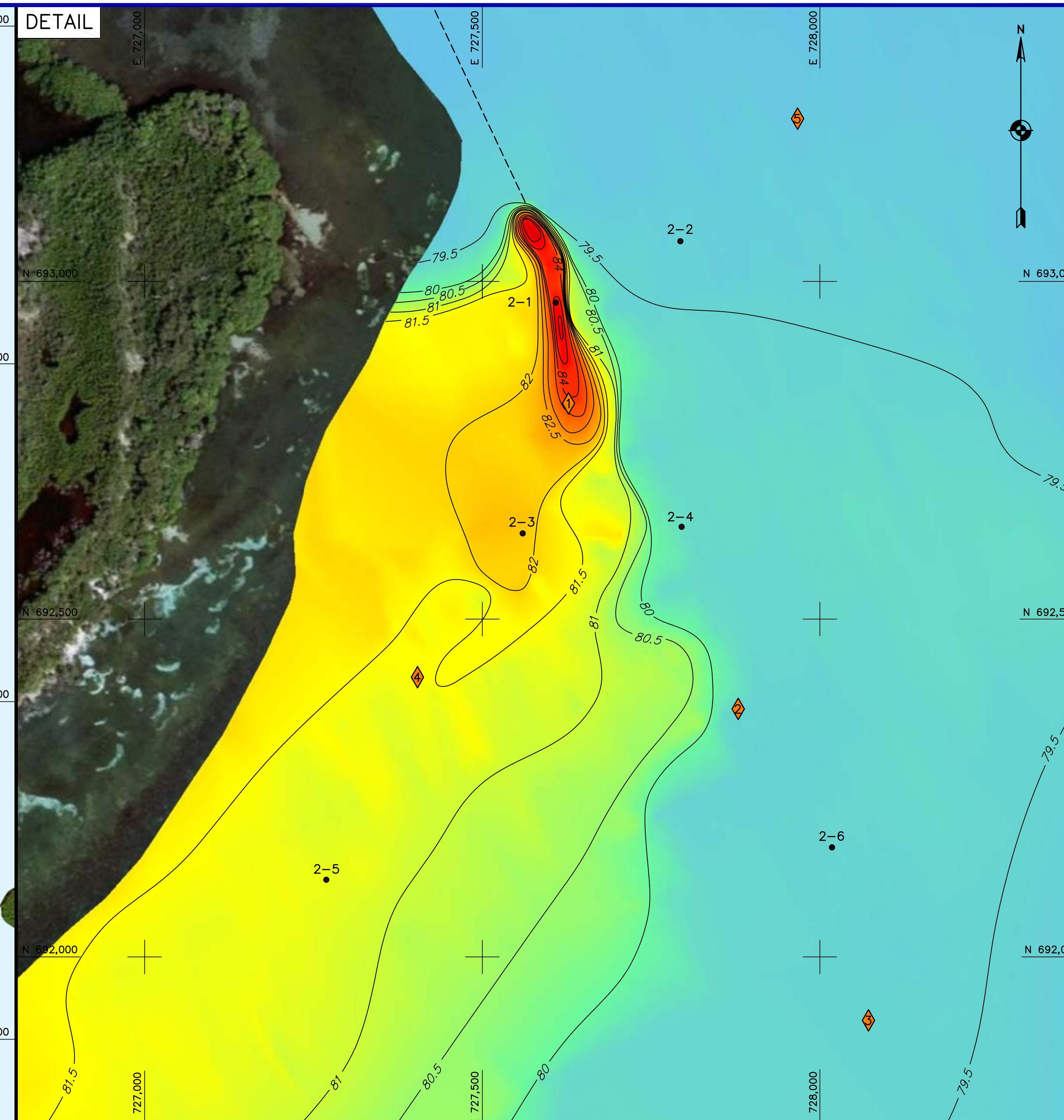
NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
4. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYA, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 14-15 MARCH 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388-4631
www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #1 - 05:00 - 07:18 Hrs - 14 March 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico





LEGEND:

1–1 CTD CAST

TEMPERATURE MOORING

–80– TEMPERATURE CONTOUR °F

– – – DISCHARGE PIPE

TEMPERATURE °F

77 79 81 83 85 87

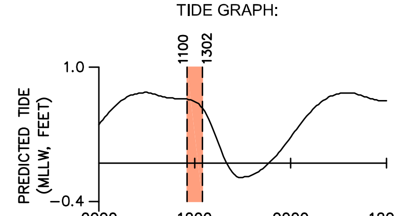
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:



NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.

2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.

3. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.

4. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYA, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.

5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 14–15 MARCH 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

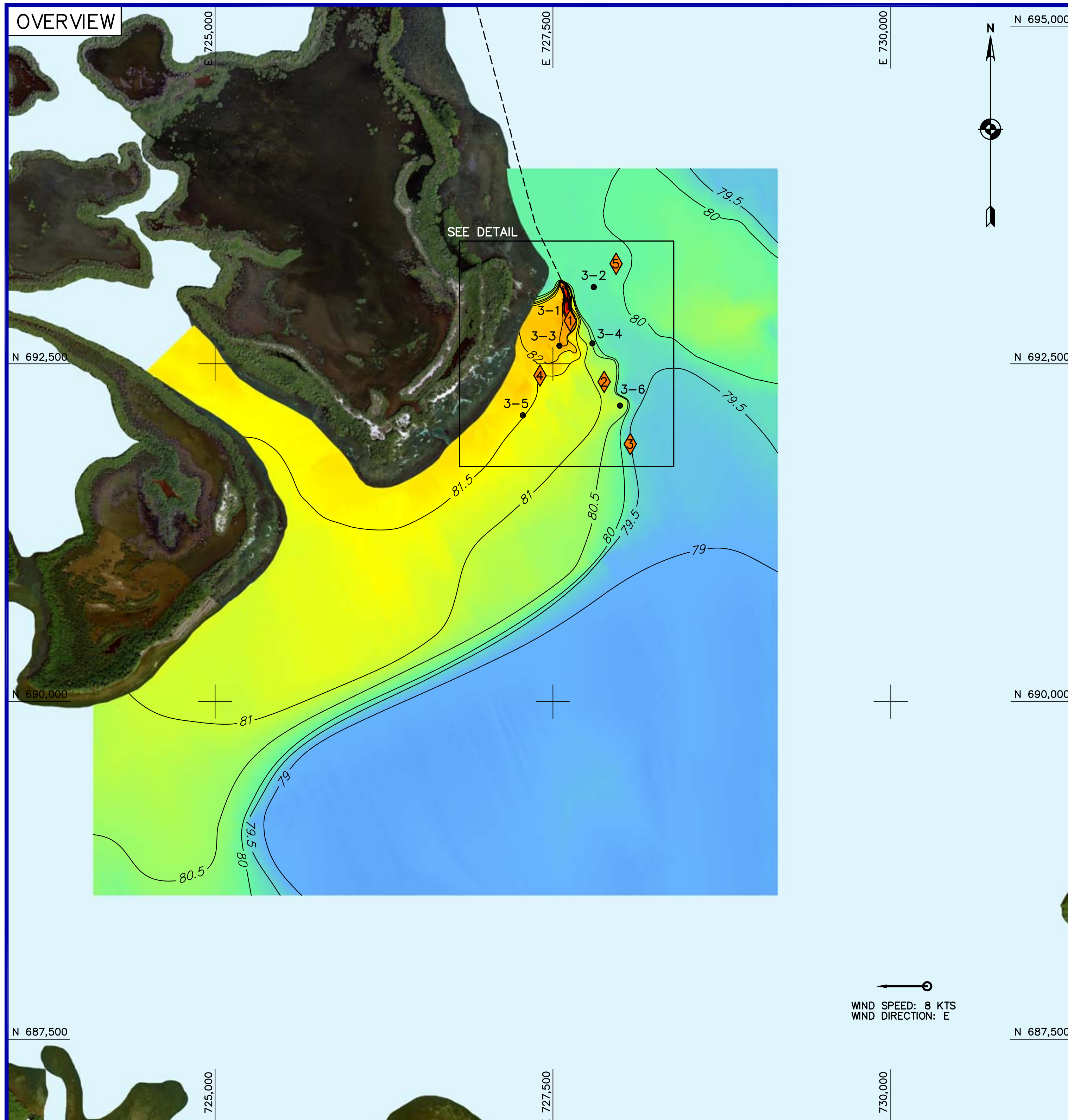
OCEAN SURVEYS, INC.

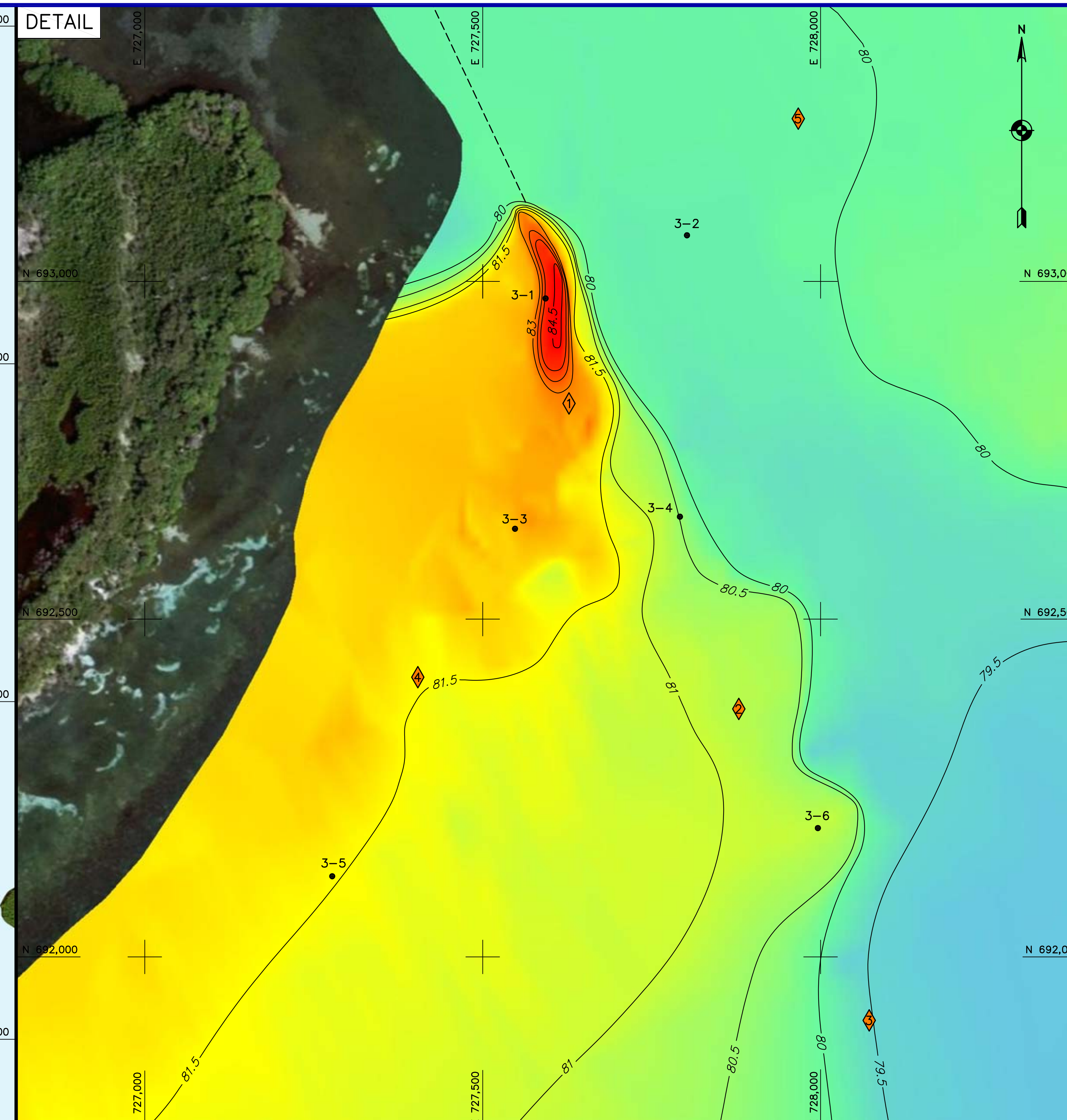
OLD SAYBROOK, CONNECTICUT

(860) 388–4631

www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #2 - 11:00 - 13:02 Hrs - 14 March 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico





LEGEND:

1–1 CTD CAST

TEMPERATURE MOORING

—80— TEMPERATURE CONTOUR °F

– – – DISCHARGE PIPE

TEMPERATURE °F

77 79 81 83 85 87

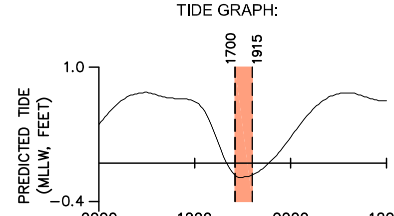
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:

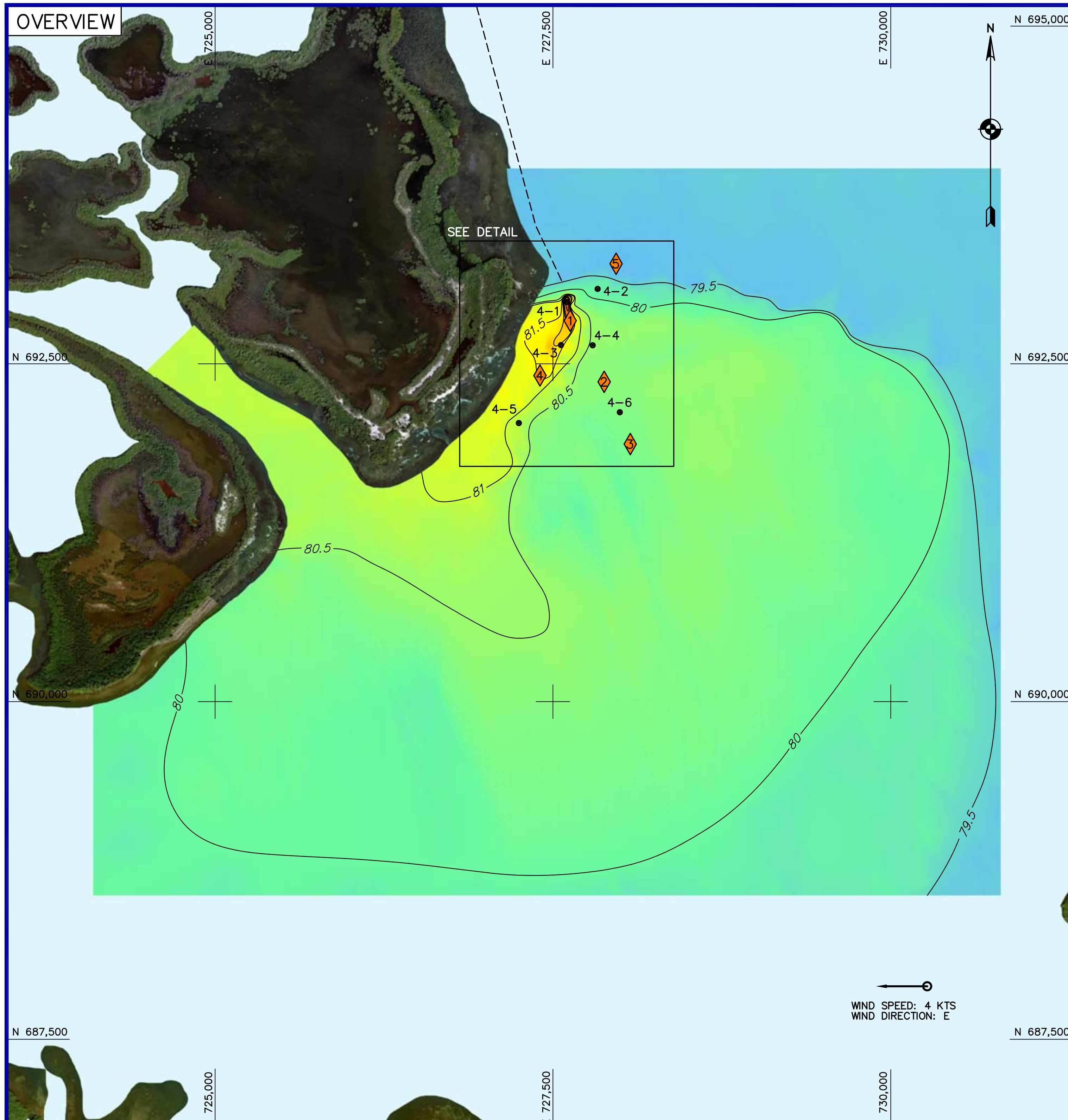


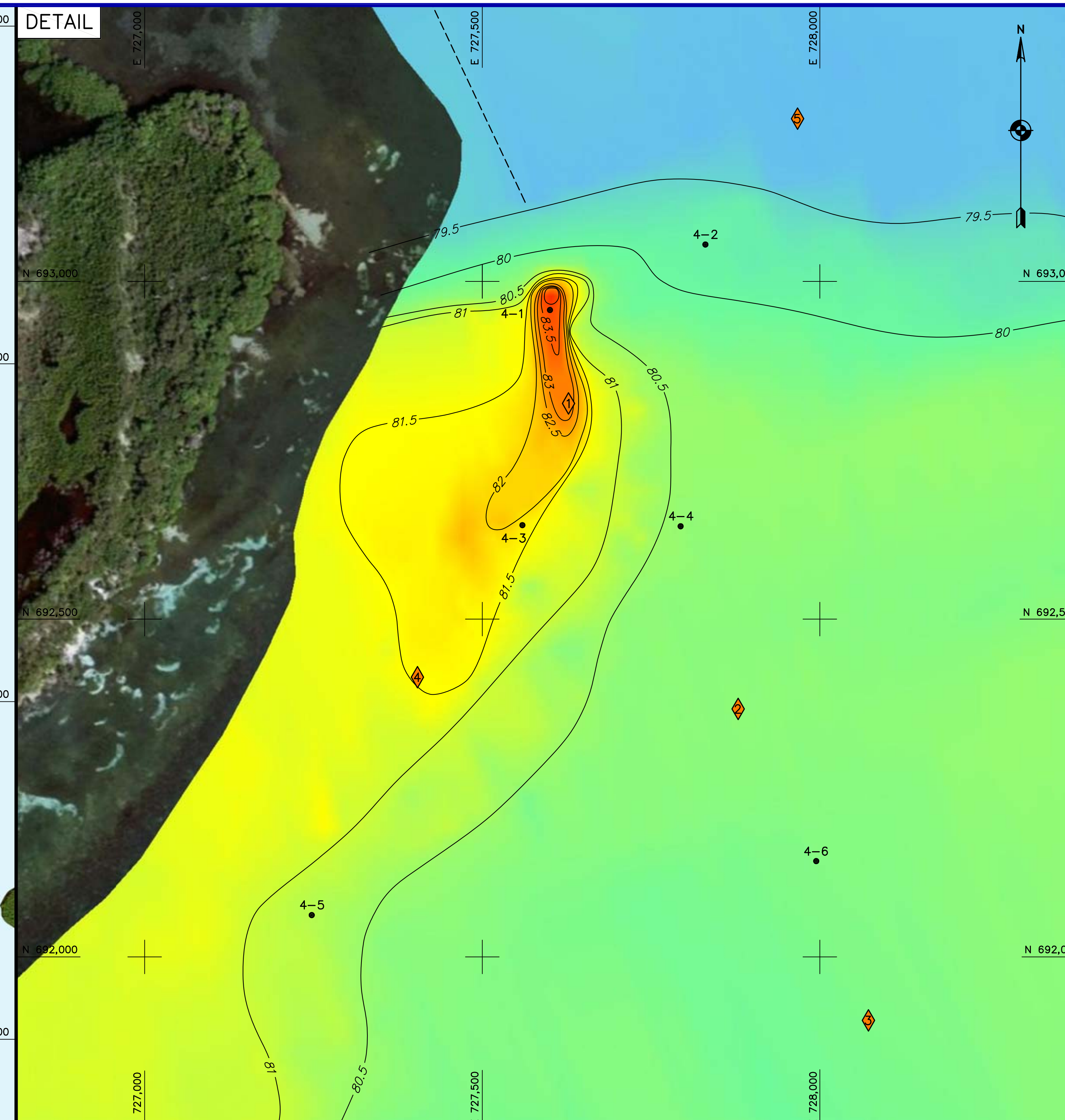
NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
4. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYA, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 14–15 MARCH 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388-4631
www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #3 - 17:00 - 19:15 Hrs - 14 March 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico





LEGEND:

1-1 CTD CAST

TEMPERATURE MOORING

—80— TEMPERATURE CONTOUR °F

– – – DISCHARGE PIPE

TEMPERATURE °F

77 79 81 83 85 87

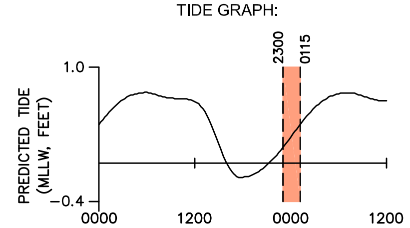
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:

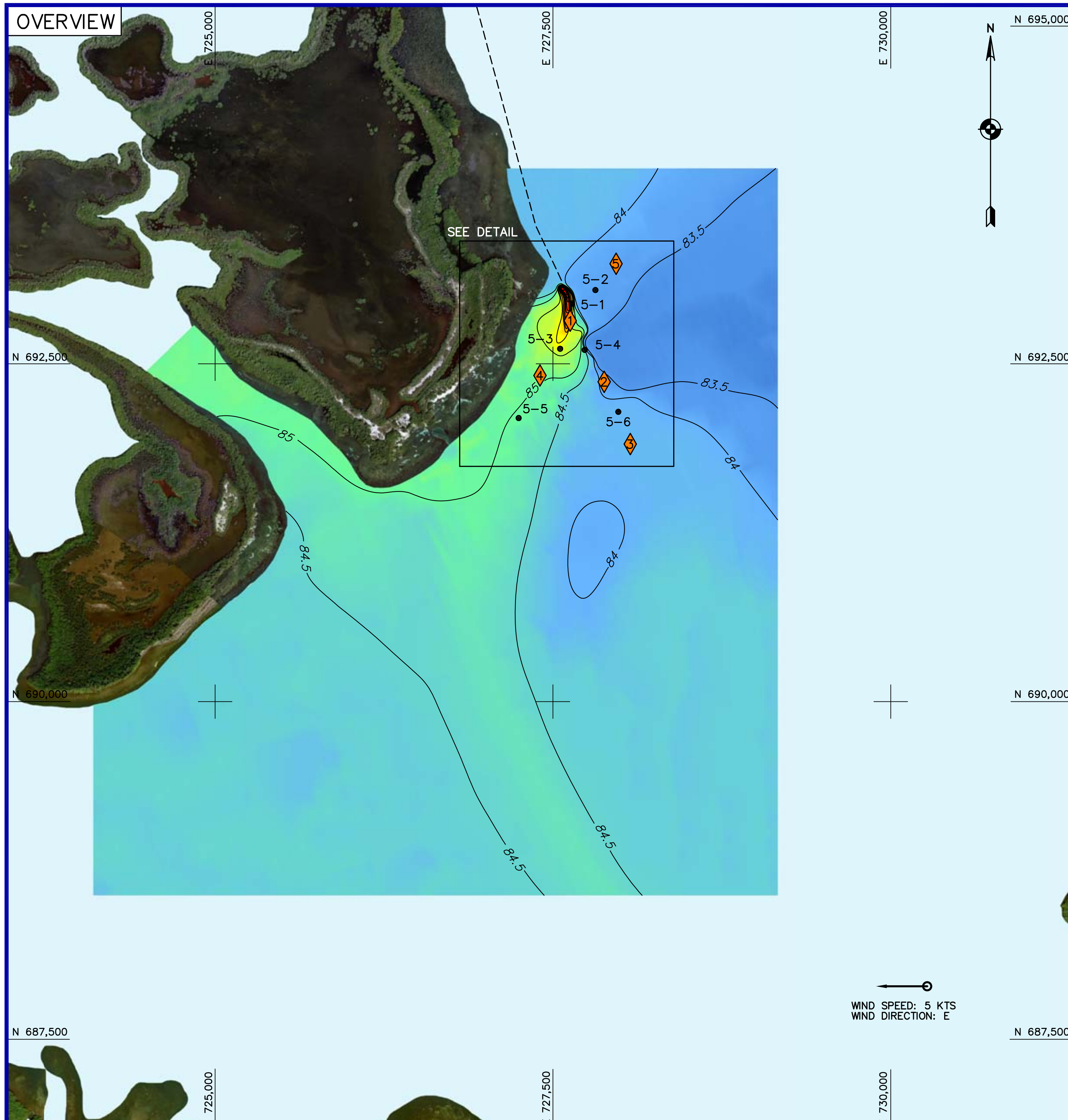


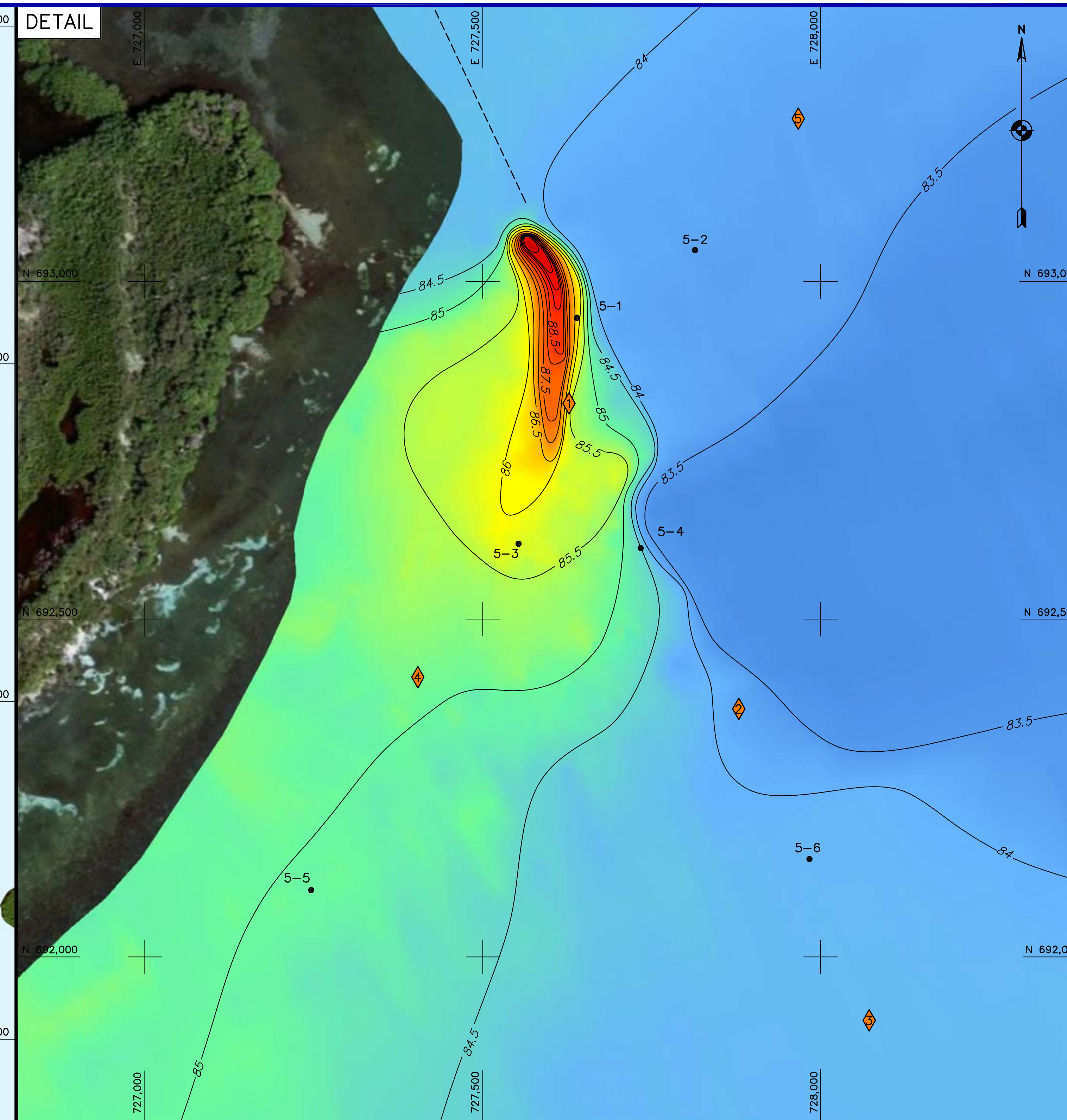
NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
4. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYA, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 14-15 MARCH 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388-4631
www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #4 - 23:00 - 01:15 Hrs - 14-15 March 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico





LEGEND:

1-1 CTD CAST

TEMPERATURE MOORING

—80— TEMPERATURE CONTOUR °F

– – – DISCHARGE PIPE

TEMPERATURE °F

82 84 86 88 90 92

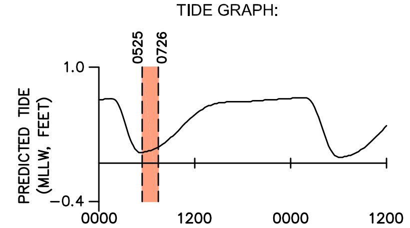
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:

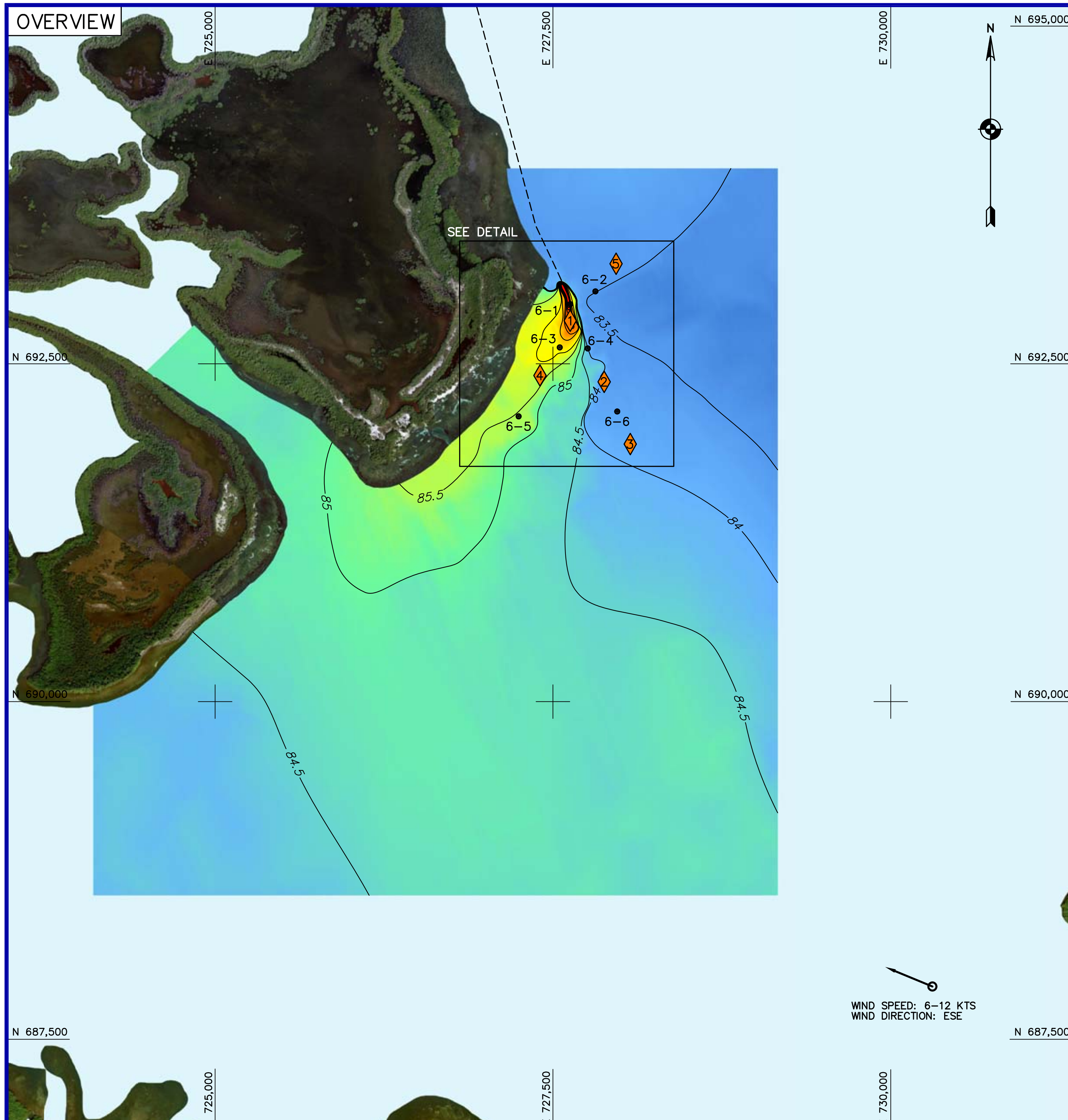


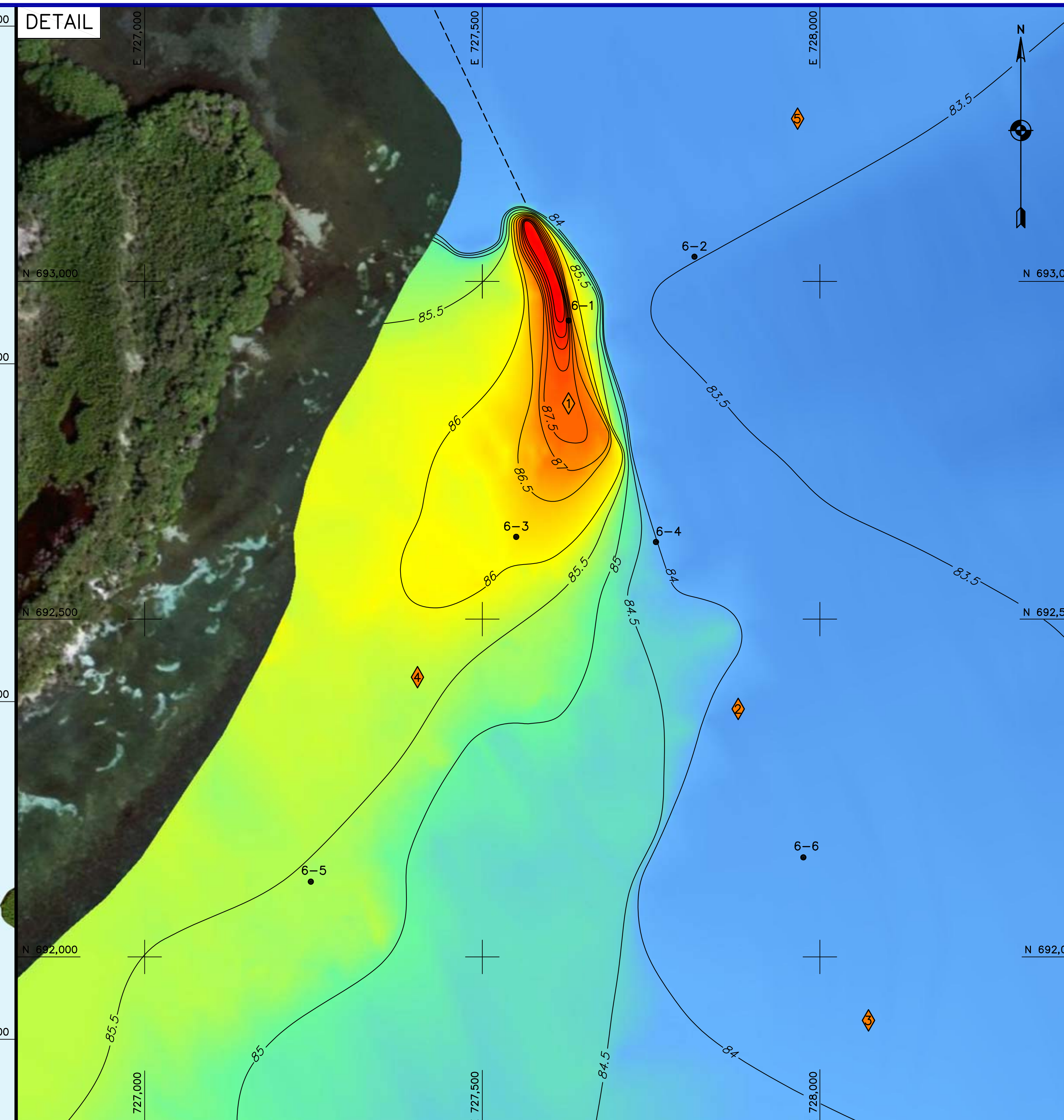
NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYO, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
4. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 8 AUGUST 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388-4631
www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #5 - 05:25 - 07:26 Hrs - 8 August 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico





LEGEND:

1-1 CTD CAST

TEMPERATURE MOORING

—80— TEMPERATURE CONTOUR °F

– – – DISCHARGE PIPE

TEMPERATURE °F

82 84 86 88 90 92

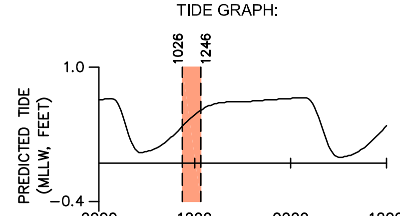
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:

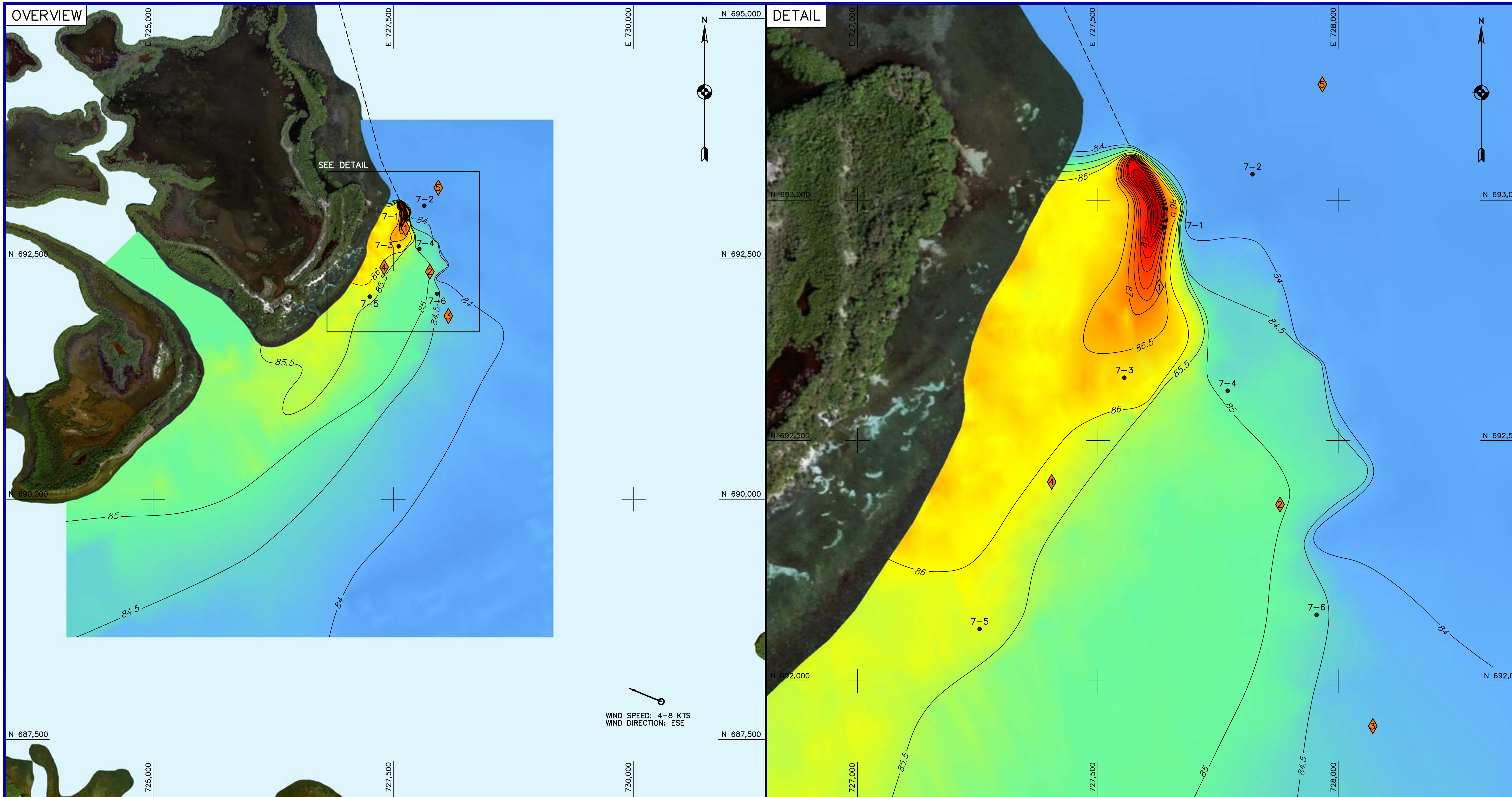


NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYO, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
4. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 8 AUGUST 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388-4631
www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #6 - 10:26 - 12:46 Hrs - 8 August 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico



LEGEND:

1-1 CTD CAST

TEMPERATURE MOORING

-80- TEMPERATURE CONTOUR °F

--- DISCHARGE PIPE

TEMPERATURE °F

82 84 86 88 90 92

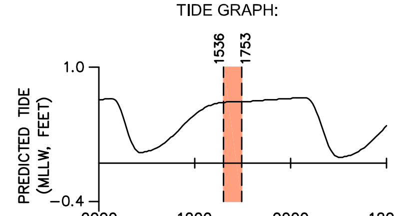
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:

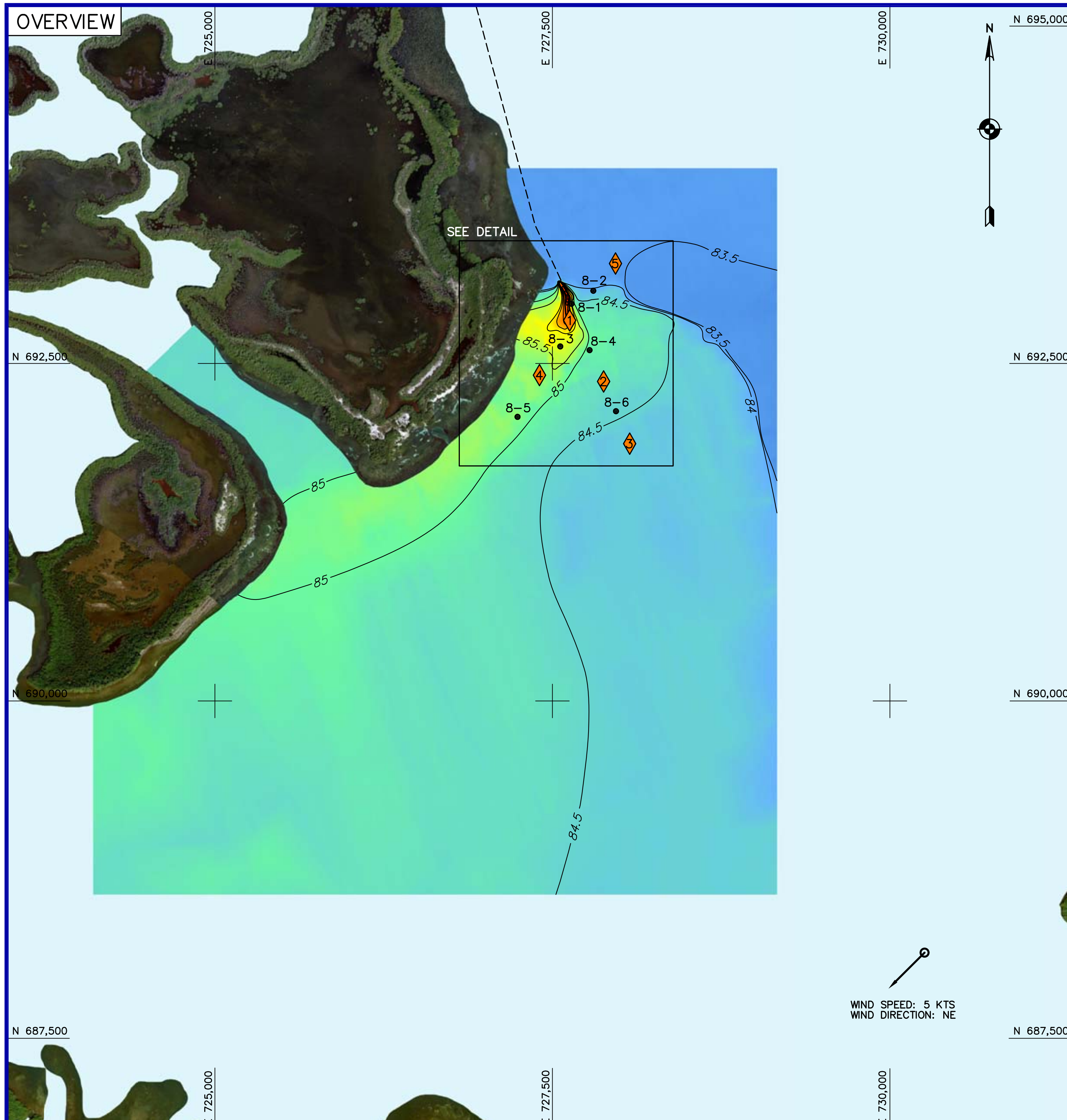


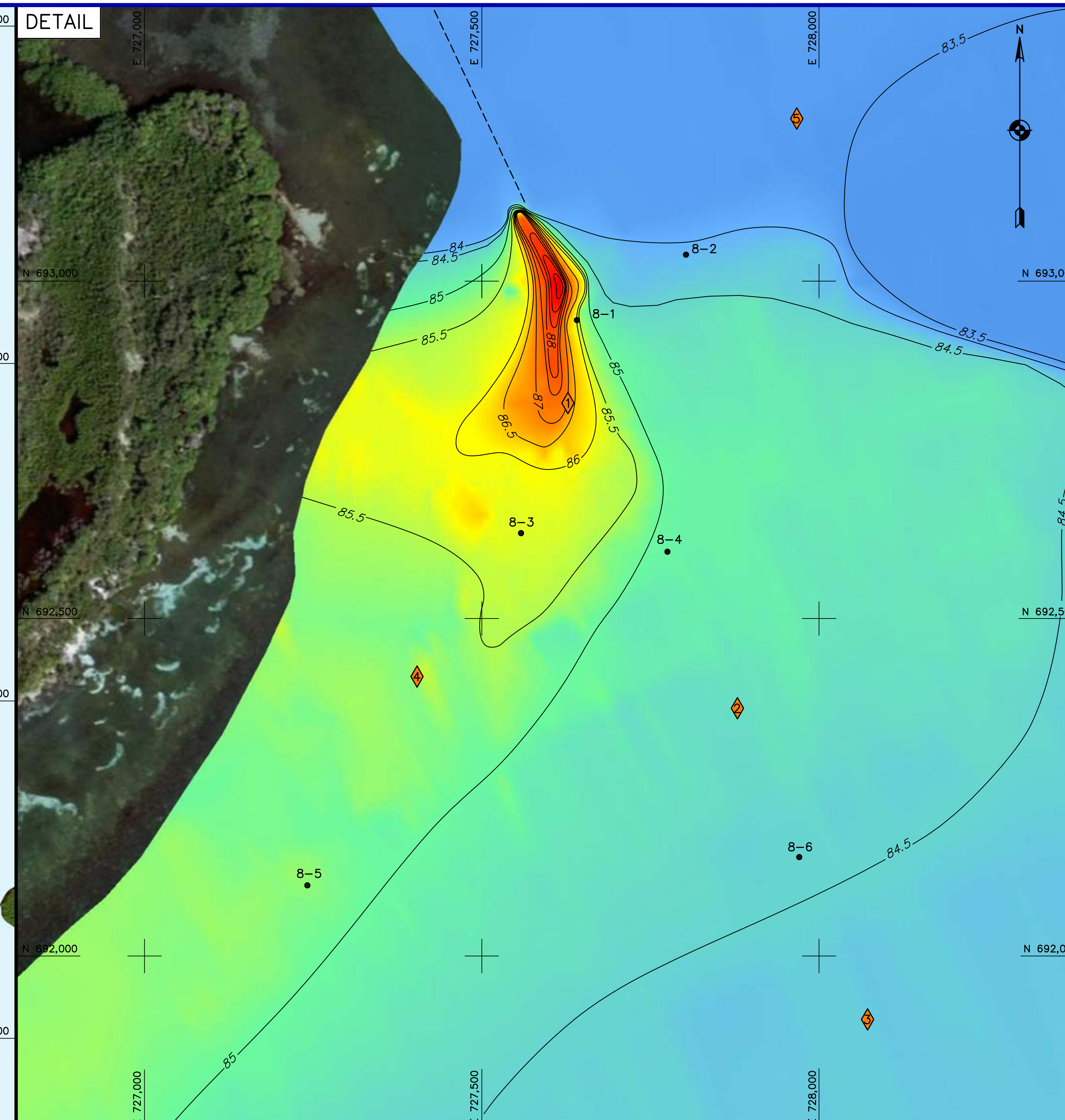
NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYO, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
4. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 8 AUGUST 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.
OLD SAYBROOK, CONNECTICUT
(860) 388-4631
www.oceansurveys.com

Thermal Plume Characterization Study
Mapping #7 - 15:36 - 17:53 Hrs - 8 August 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico





LEGEND:

1-1 CTD CAST

TEMPERATURE MOORING

—80— TEMPERATURE CONTOUR °F

- - - DISCHARGE PIPE

TEMPERATURE °F

82 84 86 88 90 92

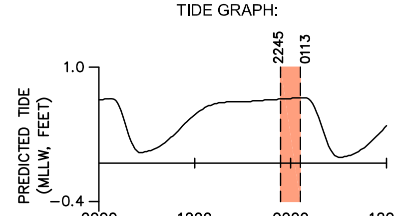
OVERVIEW SCALE: 1"=1000'

1000 0 1000

200 0 200

DETAIL SCALE: 1"=200'

TIDE GRAPH:



NOTES:

1. GRID SYSTEM IS IN FEET AND IS THE PUERTO RICO STATE PLANE COORDINATE SYSTEM, NAD 83.
2. ALL TIME REFERENCES ARE BASED ON ATLANTIC STANDARD TIME.
3. PREDICTED TIDE DATA WAS PROVIDED BY NOAA PREDICTIONS FOR THE PORT OF ARROYO, PUERTO RICO LOCATED APPROXIMATELY 9.5 NAUTICAL MILES EAST OF THE DISCHARGE.
4. SHORELINE IS APPROXIMATE AND WAS TAKEN FROM DIGITAL ORTHOPHOTO QUADRANGLES OBTAINED FROM THE USGS SEAMLESS DATA SERVER FLOWN IN 2006.
5. THE INFORMATION PRESENTED ON THIS DRAWING REPRESENTS THE RESULTS OF A SURVEY PERFORMED BY OCEAN SURVEYS, INC. ON 8 AUGUST 2012 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

OCEAN SURVEYS, INC.

OLD SAYBROOK, CONNECTICUT

(860) 388-4631

www.oceansurveys.com

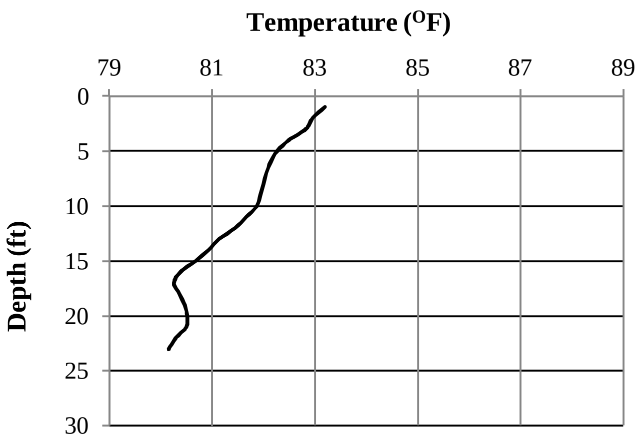
Thermal Plume Characterization Study
Mapping #8 - 22:45 - 01:13 Hrs - 8 August 2012
PREPA Aguirre Power Plant Complex
Central Aguirre, Puerto Rico

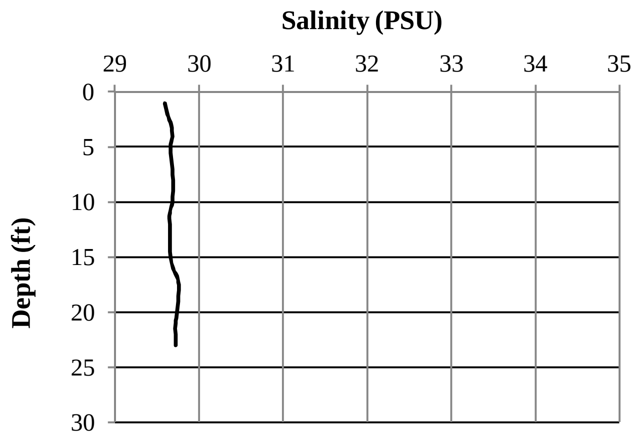
APPENDIX 4

CTD VERTICAL PROFILES

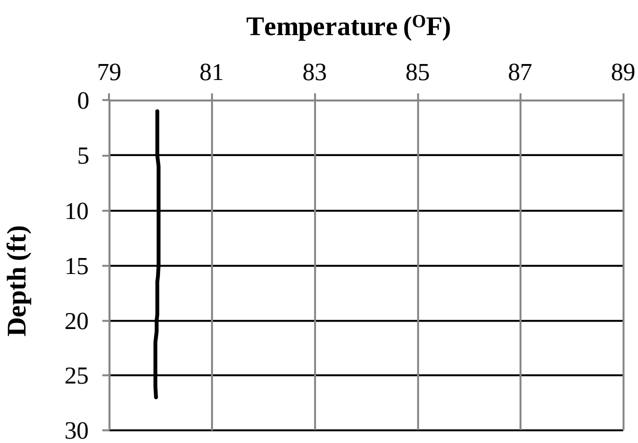
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #1
14 March 2012

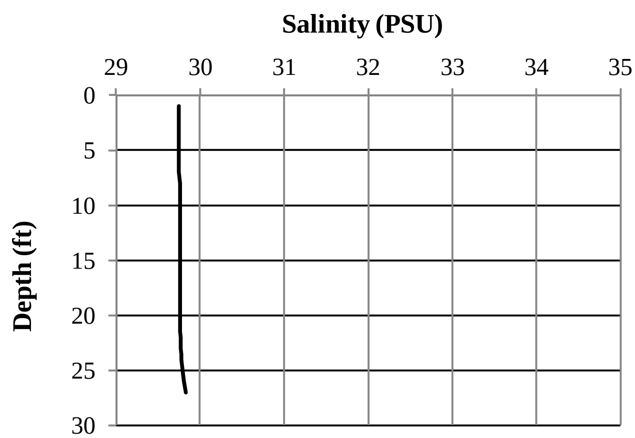
VP1-1



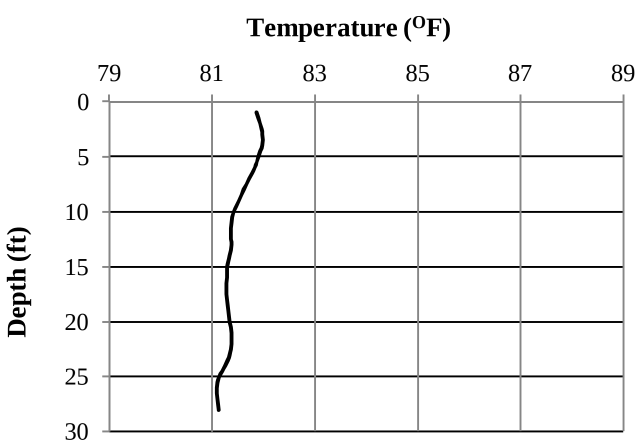


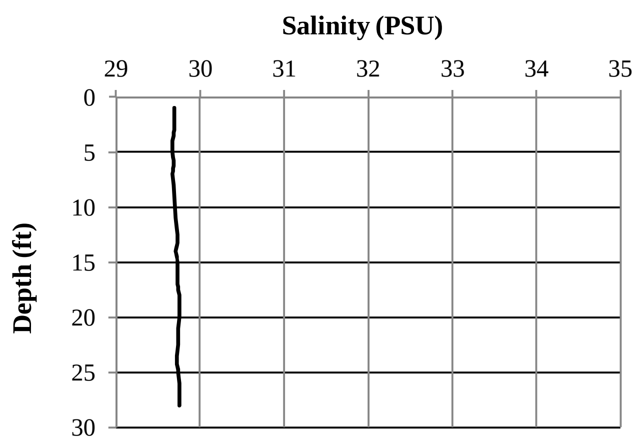
VP1-2





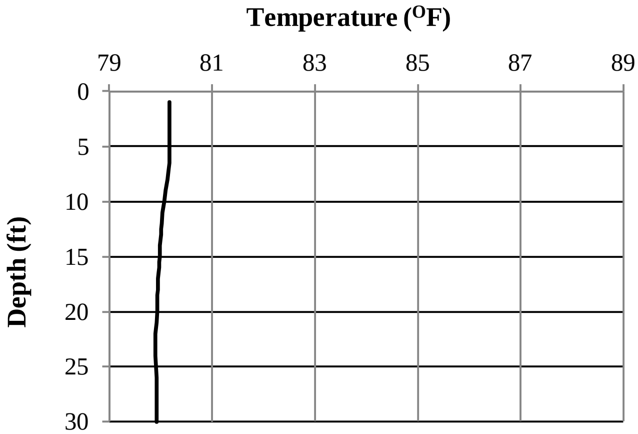
VP1-3

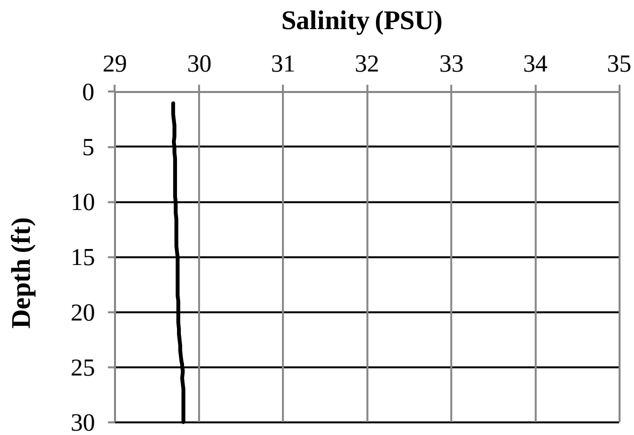




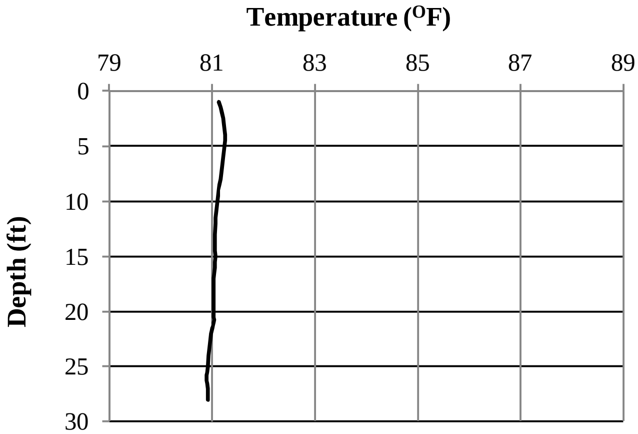
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #1
14 March 2012

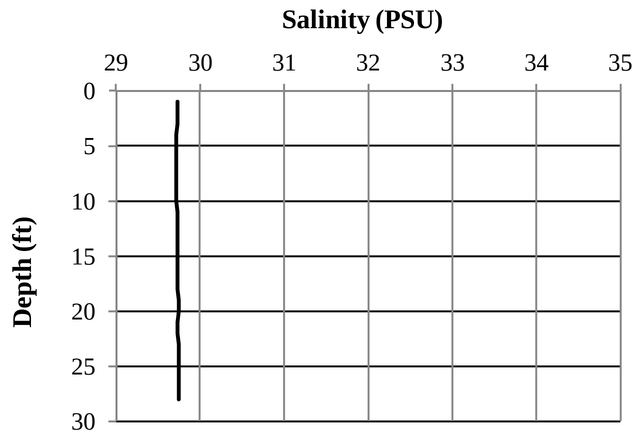
VP1-4



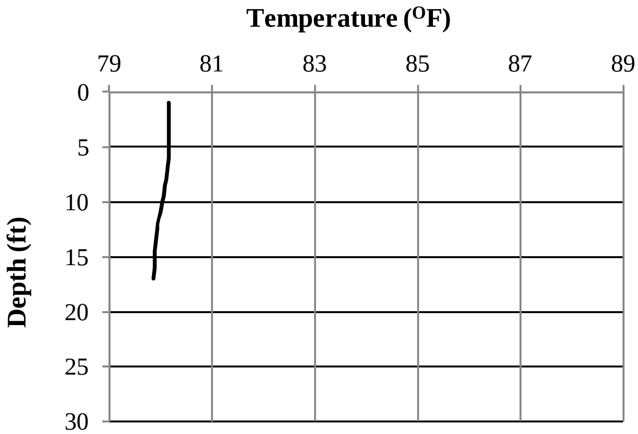


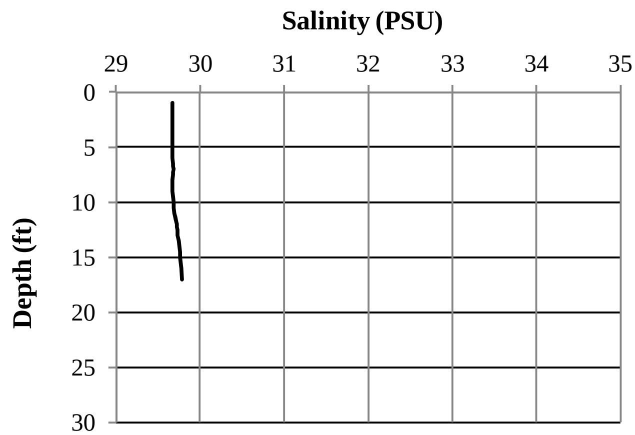
VP1-5





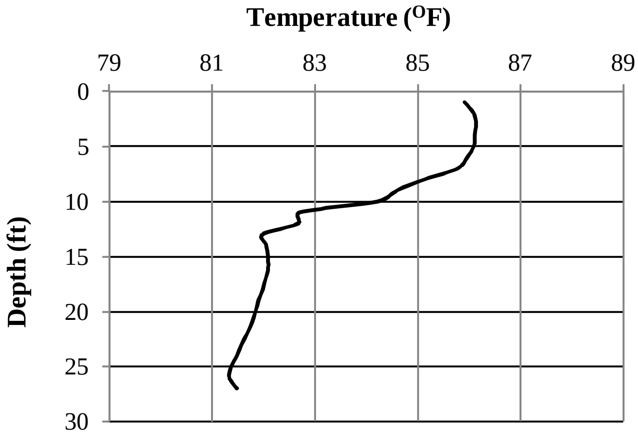
VP1-6

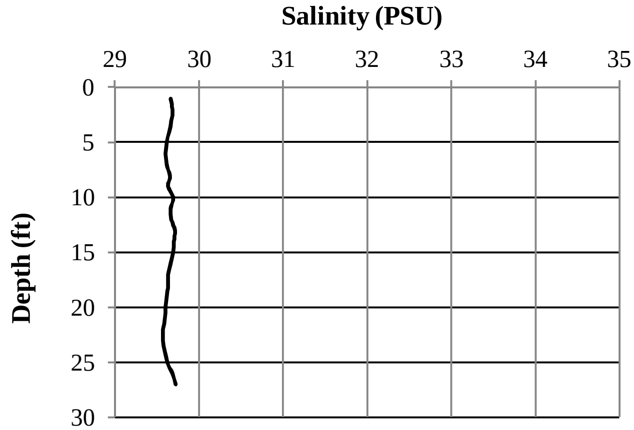




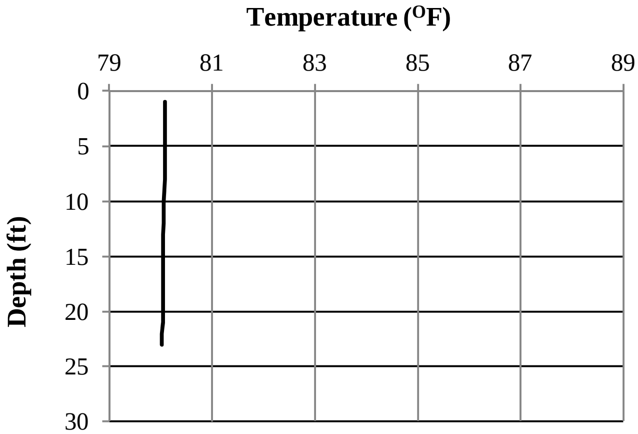
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #2
14 March 2012

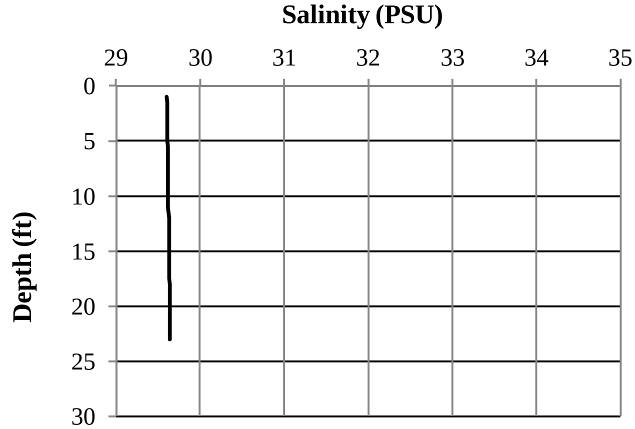
VP2-1



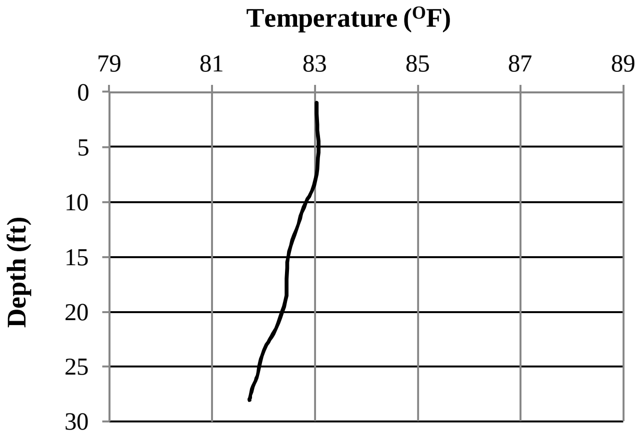


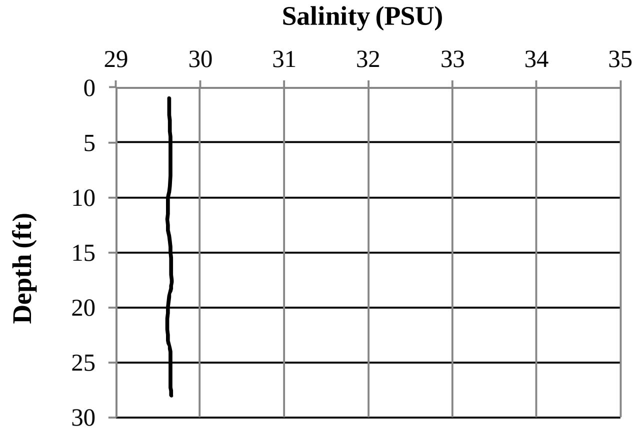
VP2-2





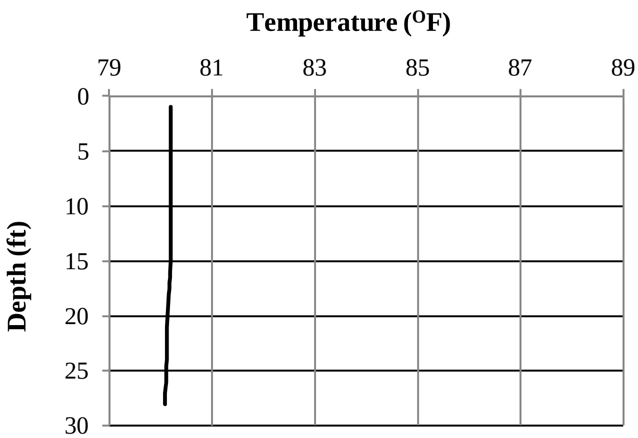
VP2-3

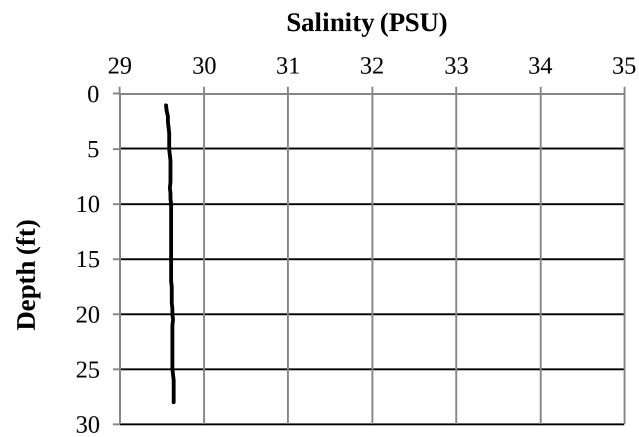




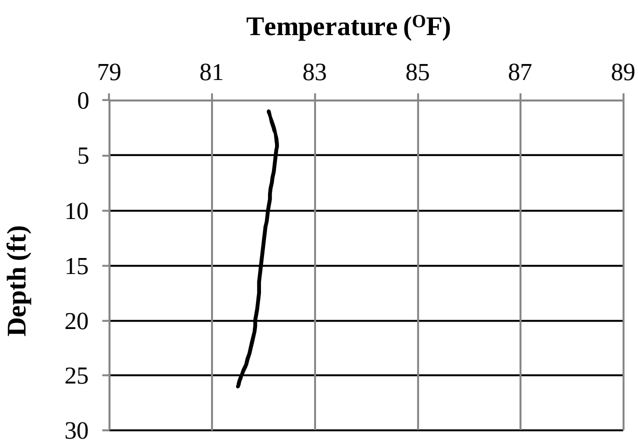
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #2
14 March 2012

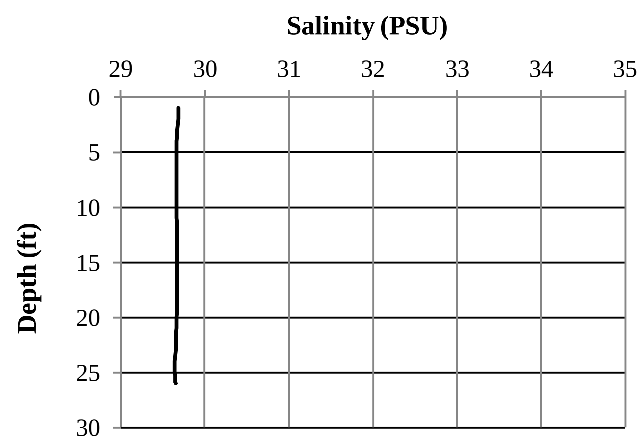
VP2-4



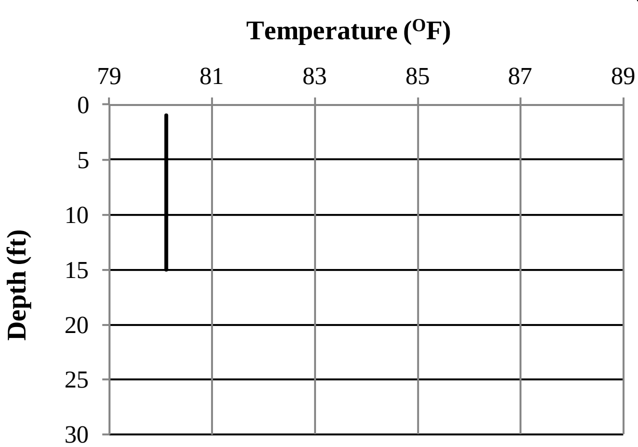


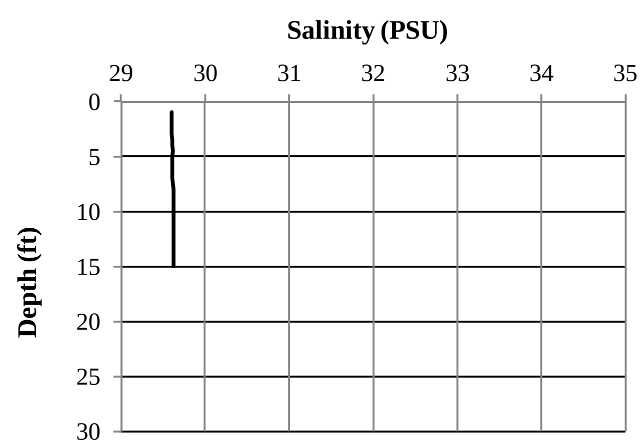
VP2-5





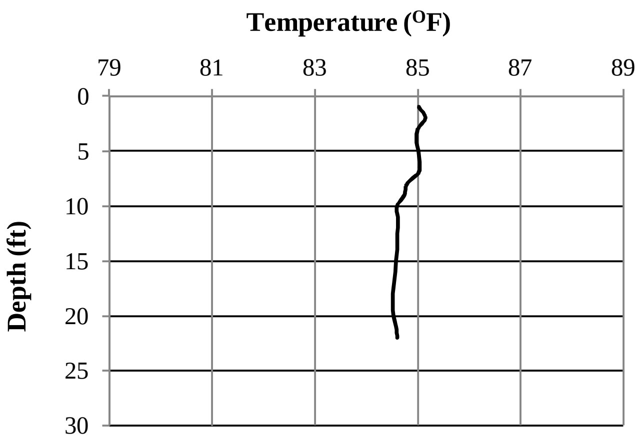
VP2-6

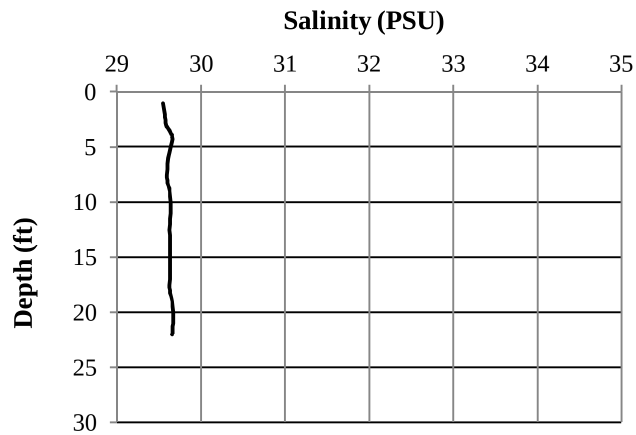




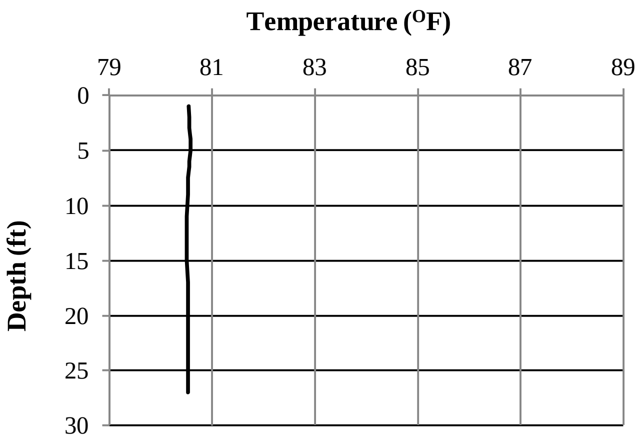
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #3
14 March 2012

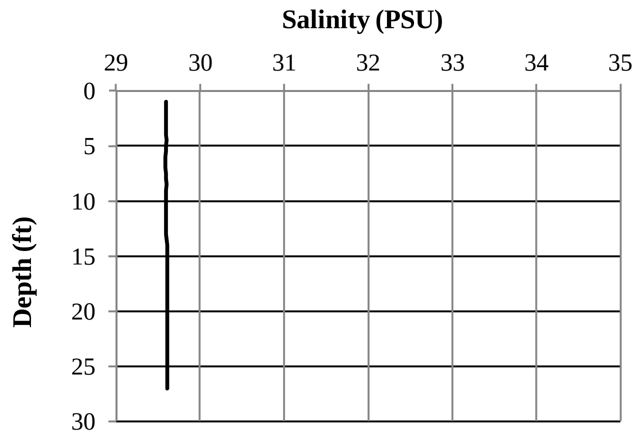
VP3-1



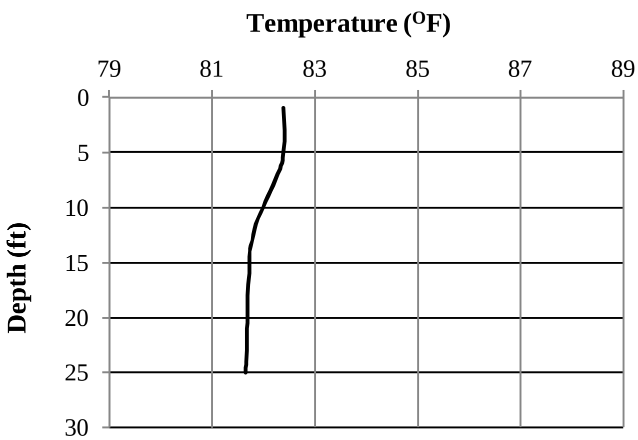


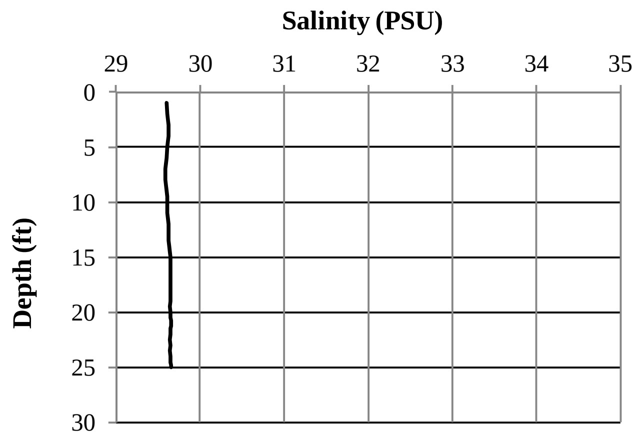
VP3-2





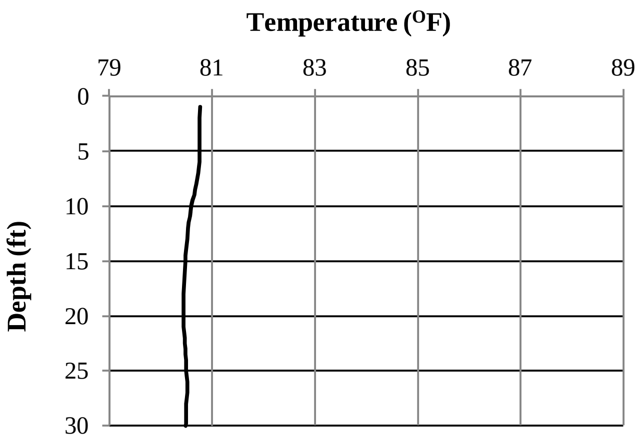
VP3-3

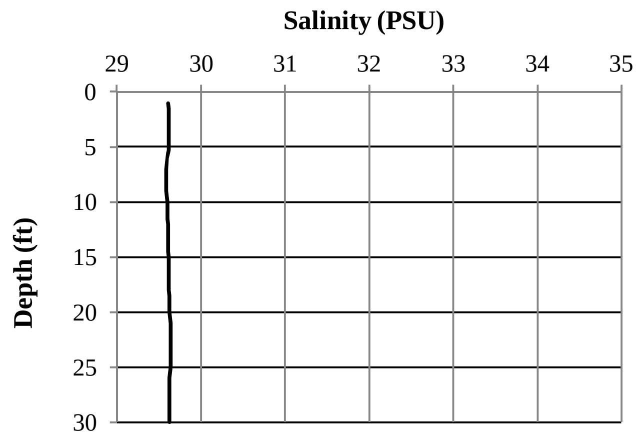




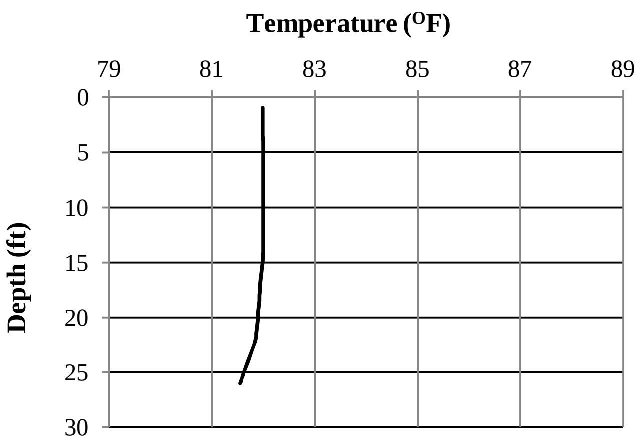
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #3
14 March 2012

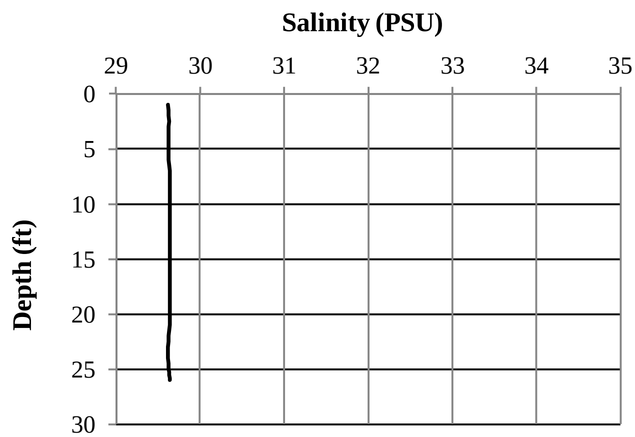
VP3-4



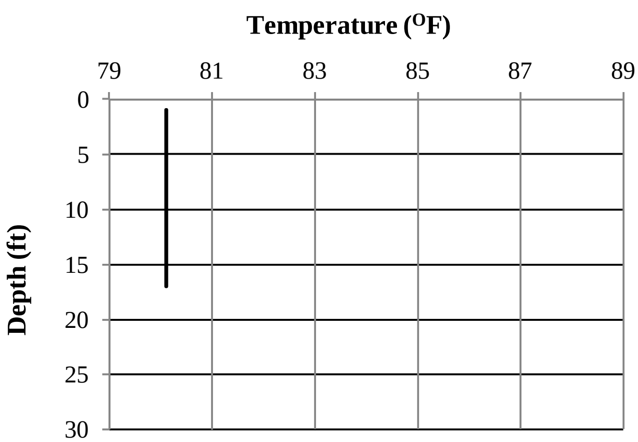


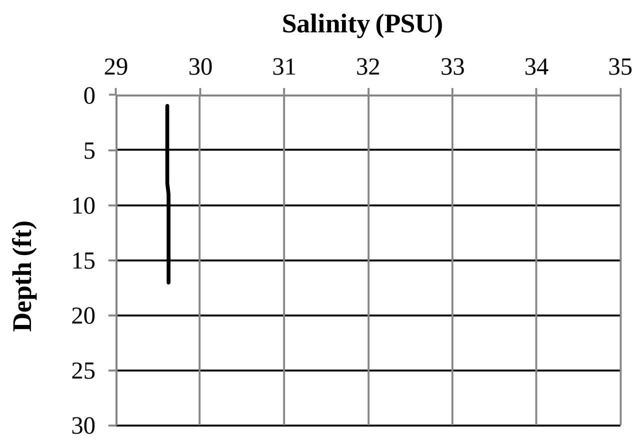
VP3-5





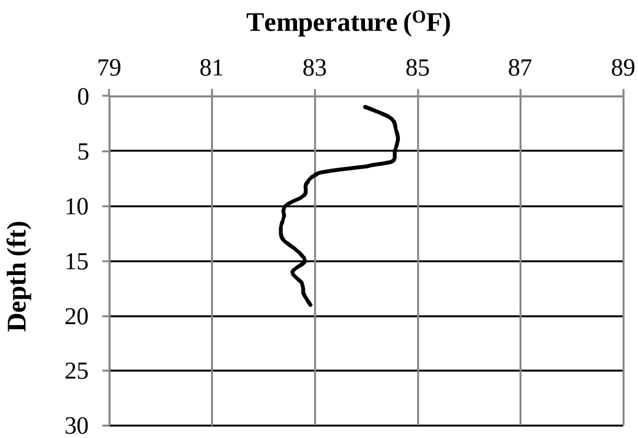
VP3-6

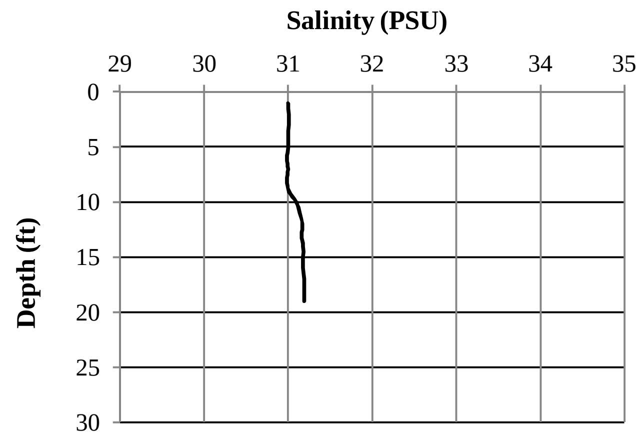




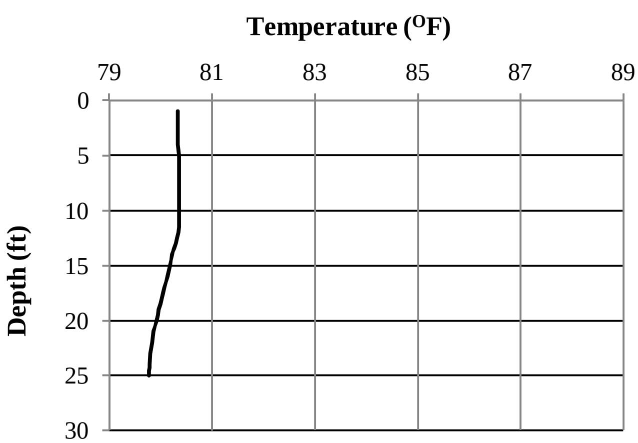
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #4
14 March 2012

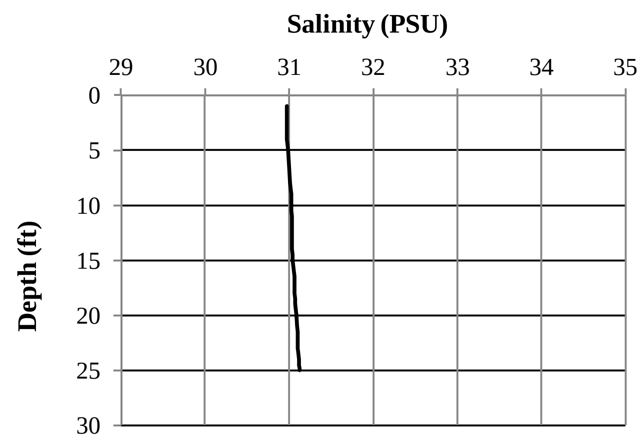
VP4-1



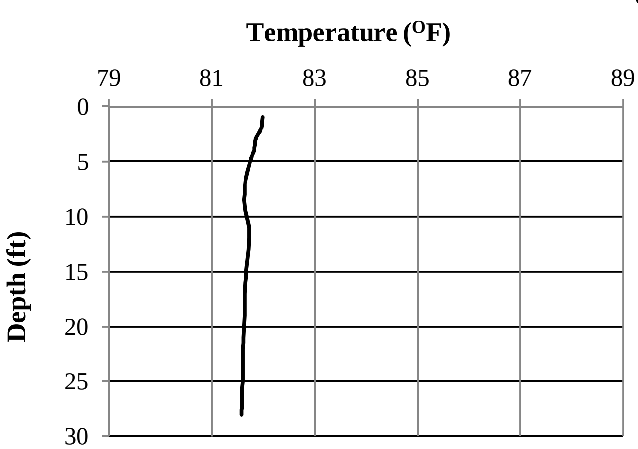


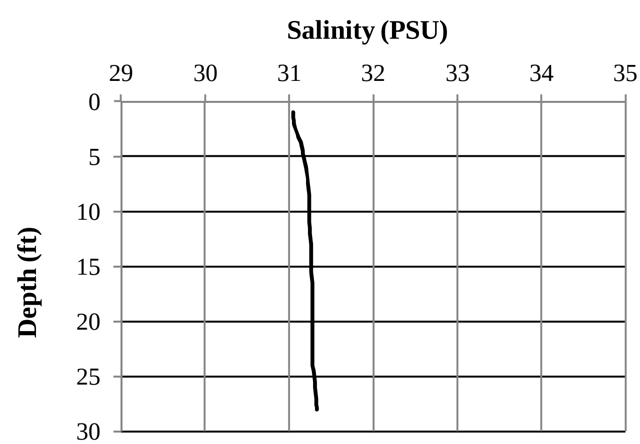
VP4-2





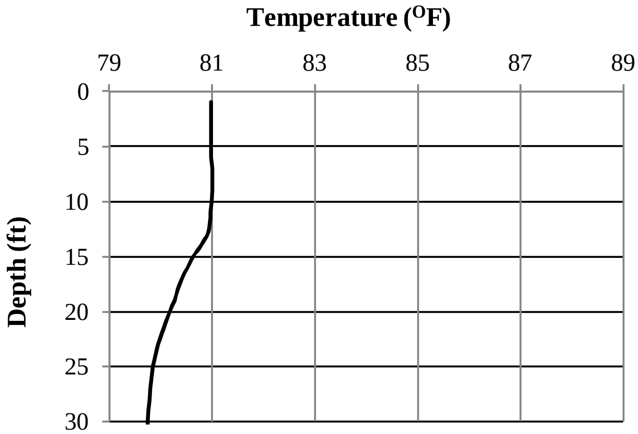
VP4-3

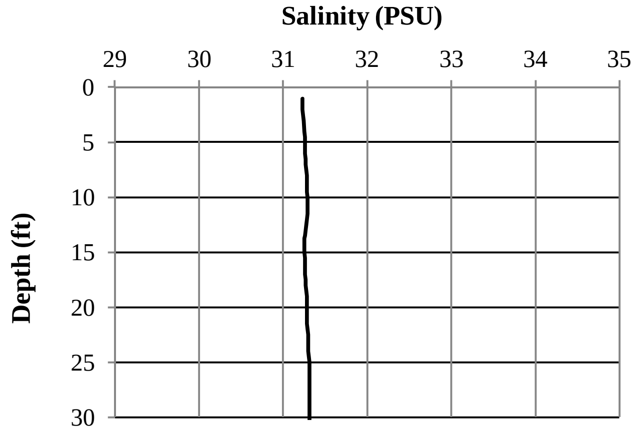




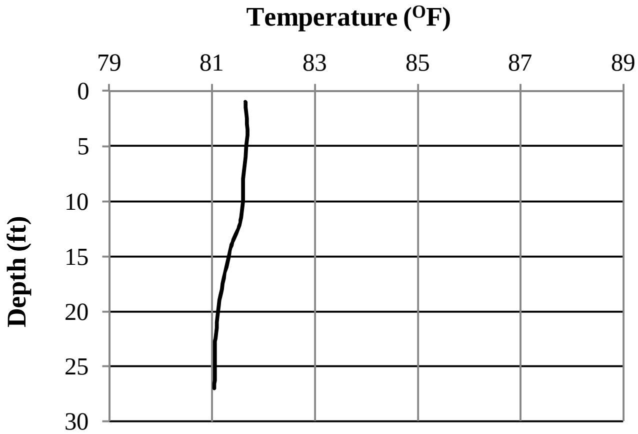
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #4
14 March 2012

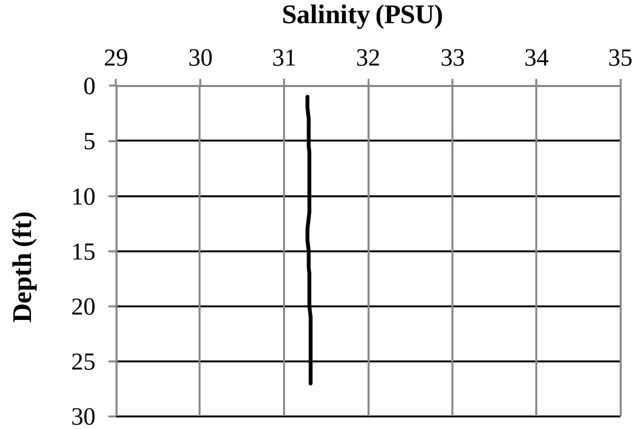
VP4-4



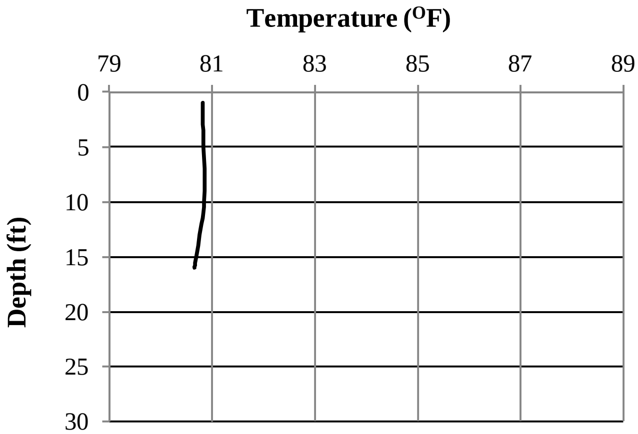


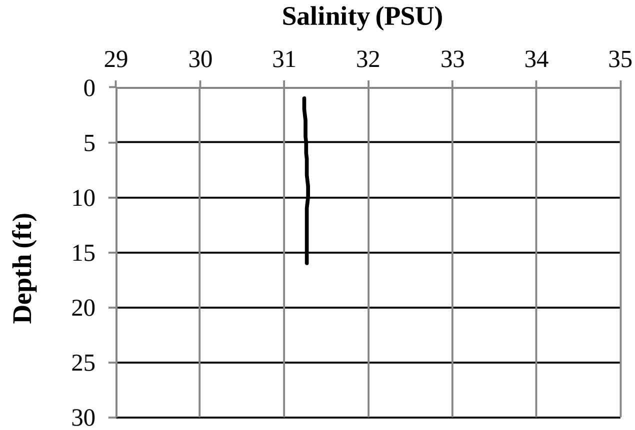
VP4-5





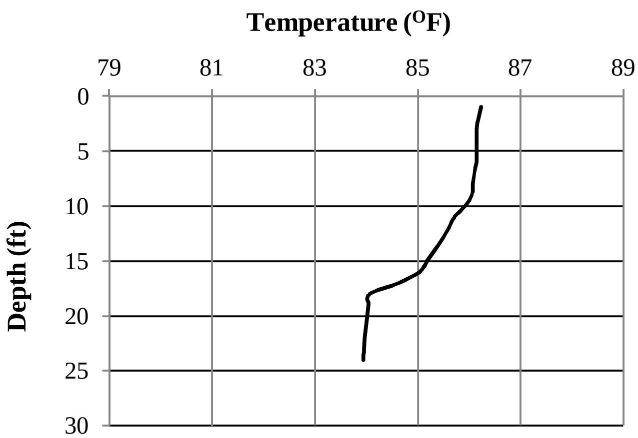
VP4-6

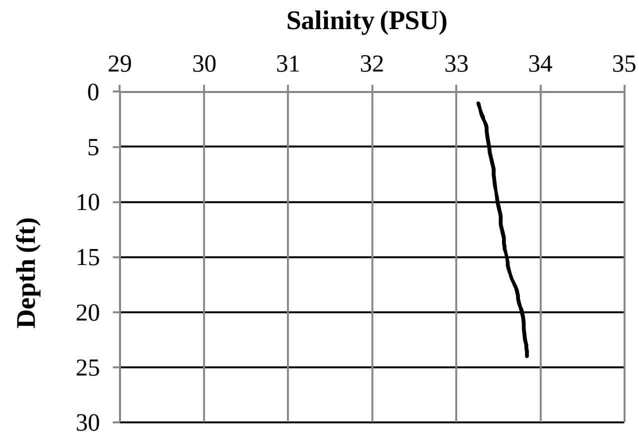




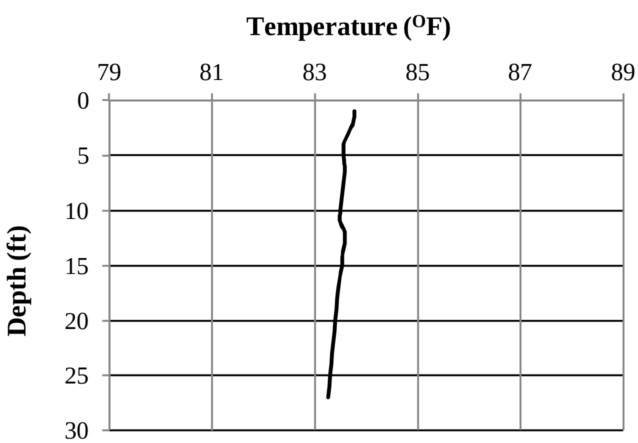
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #5
8 August 2012

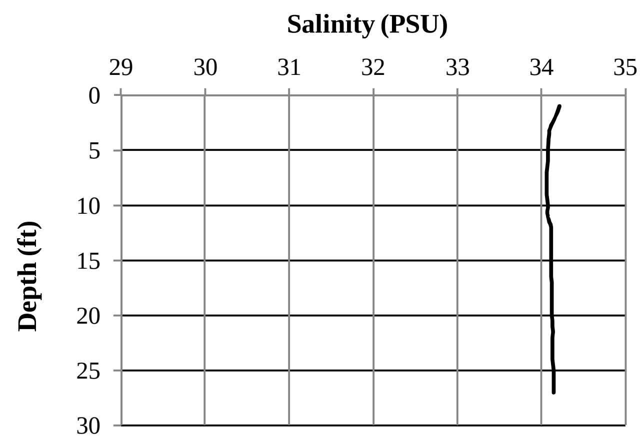
VP5-1



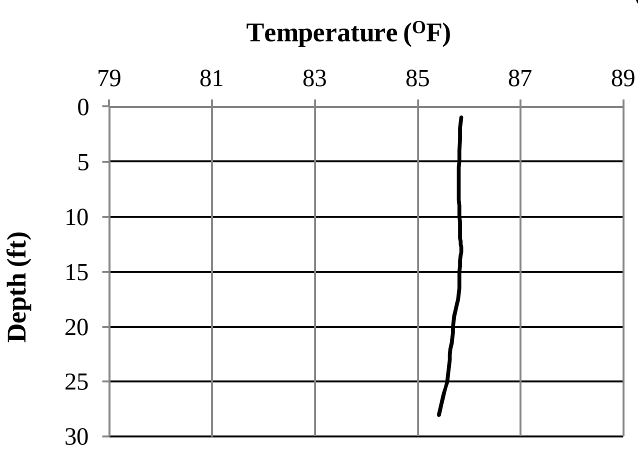


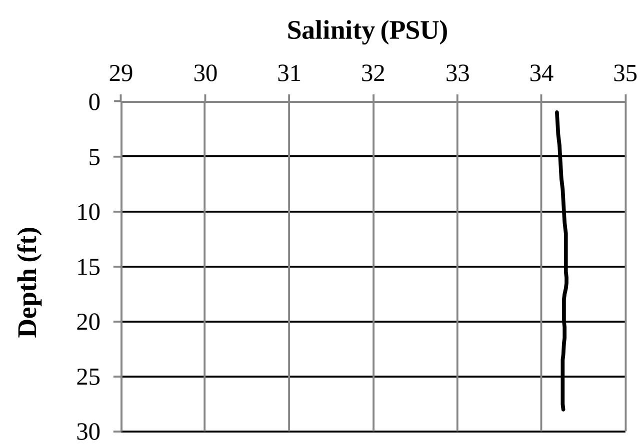
VP5-2





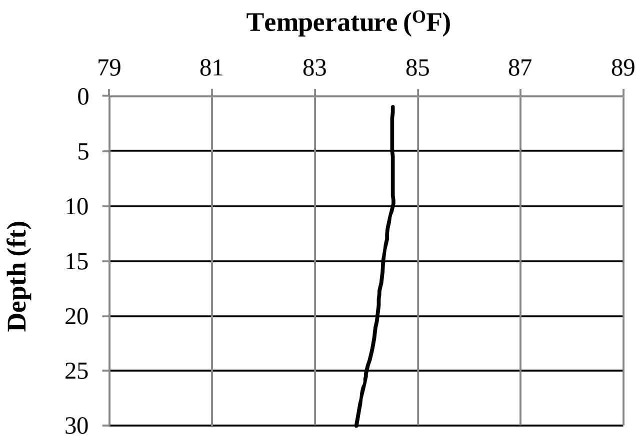
VP5-3

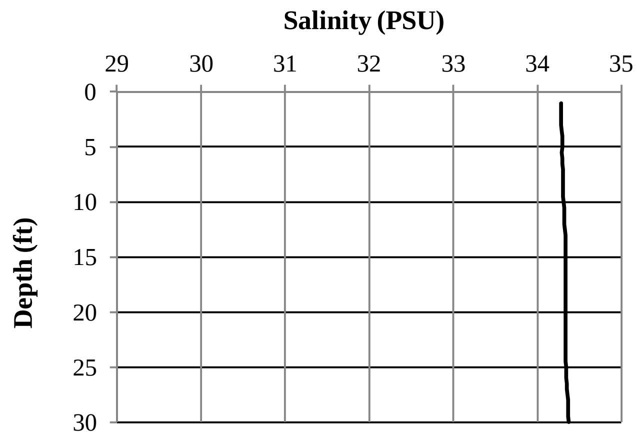




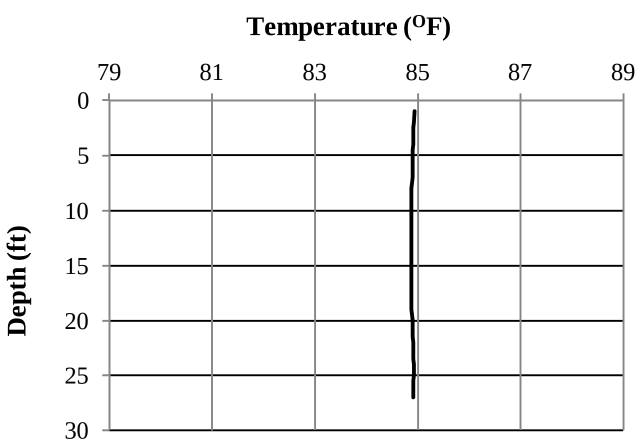
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #5
8 August 2012

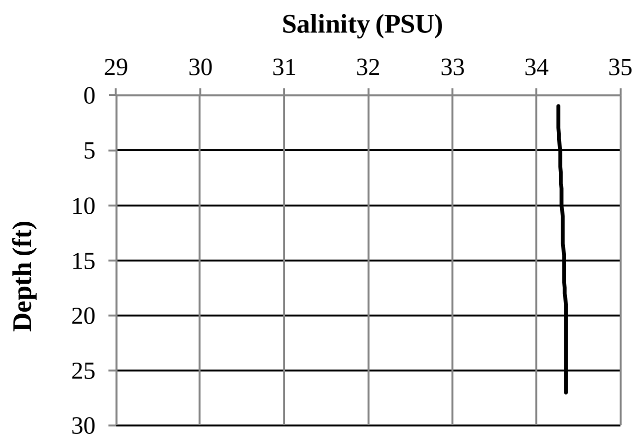
VP5-4



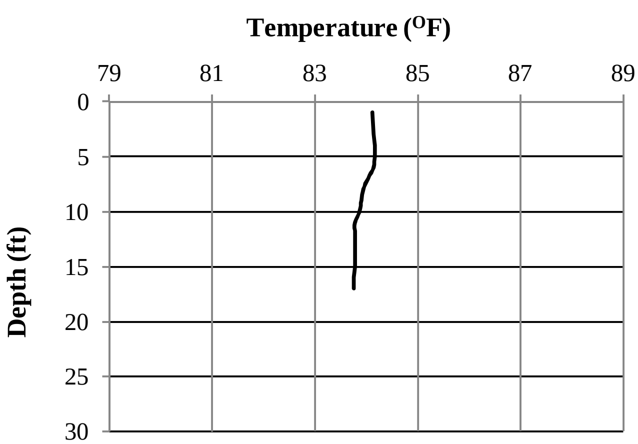


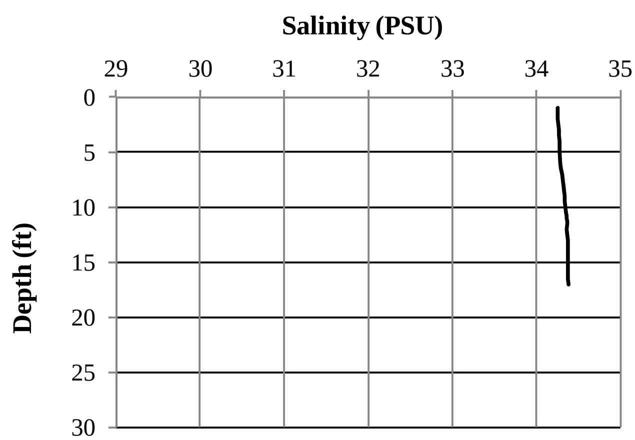
VP5-5





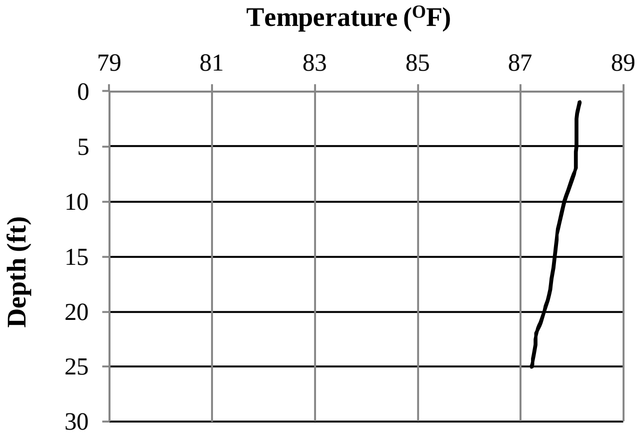
VP5-6

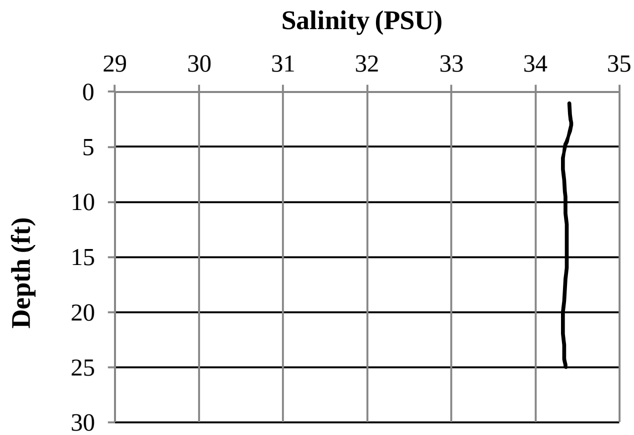




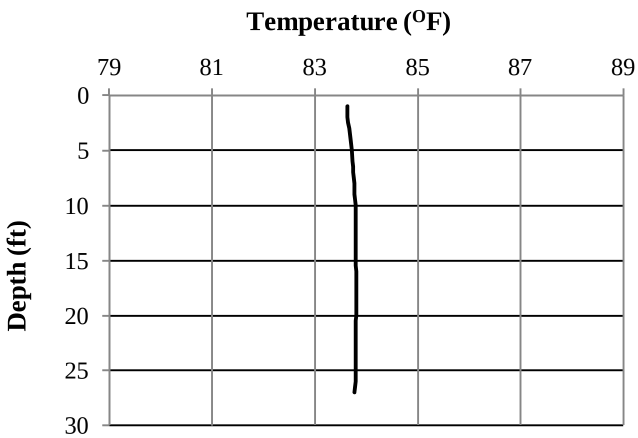
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #6
8 August 2012

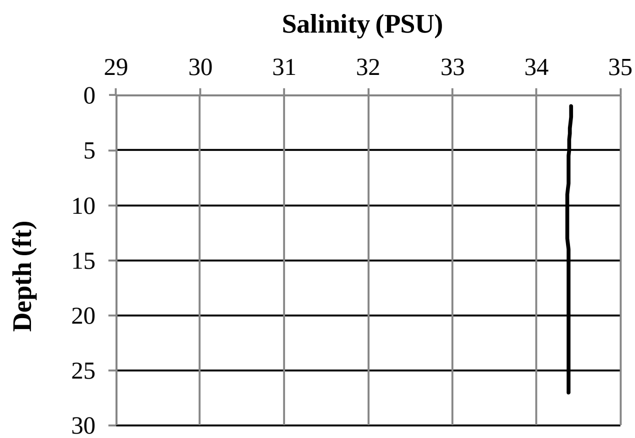
VP6-1



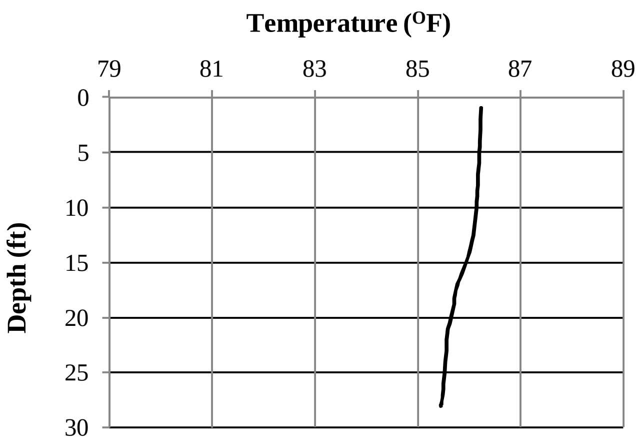


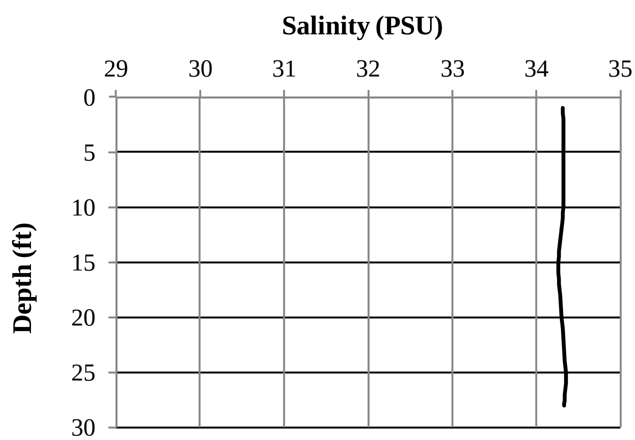
VP6-2





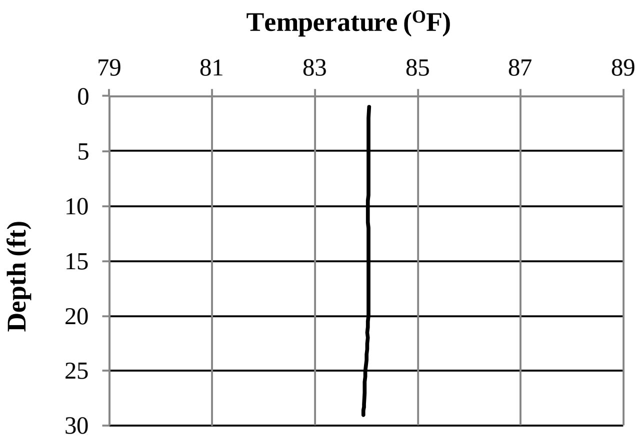
VP6-3

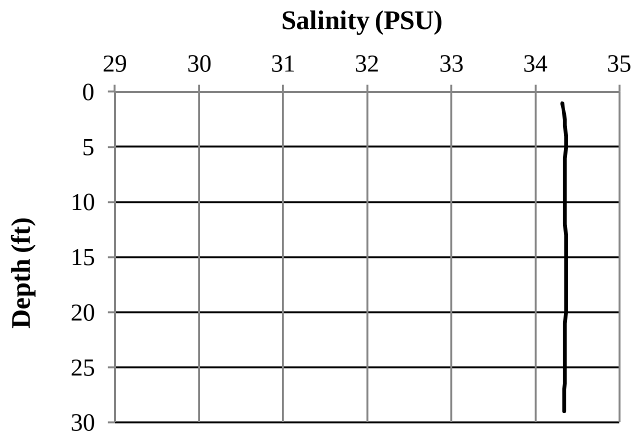




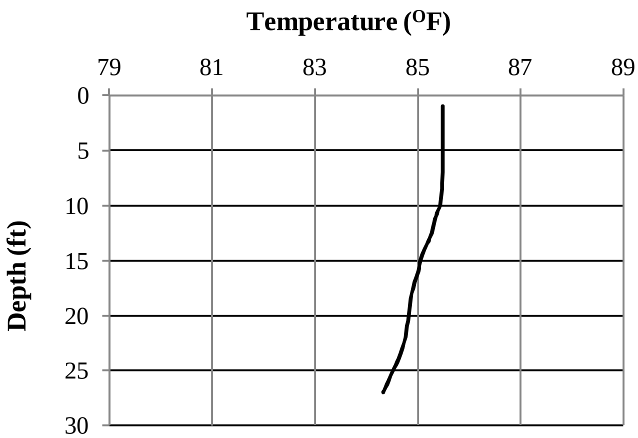
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #6
8 August 2012

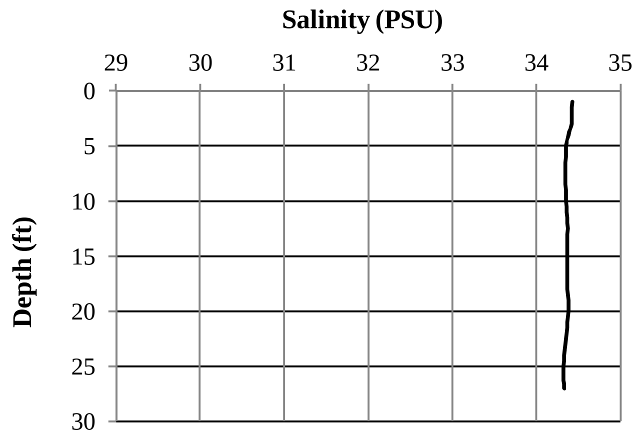
VP6-4



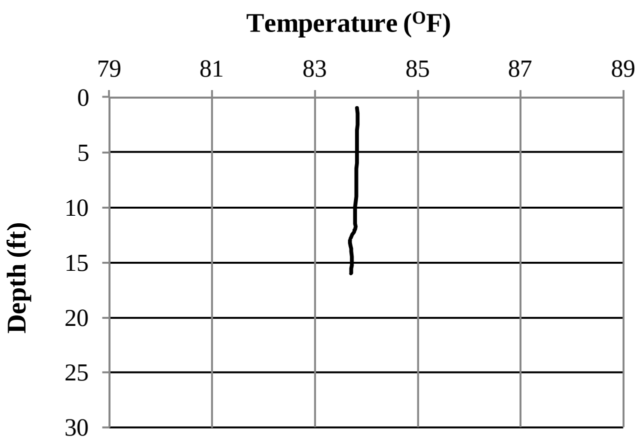


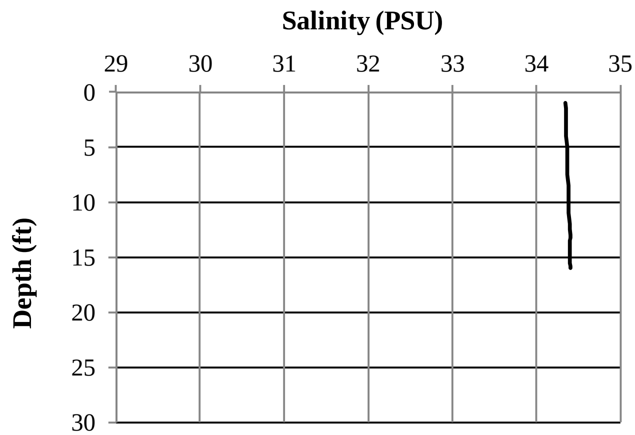
VP6-5





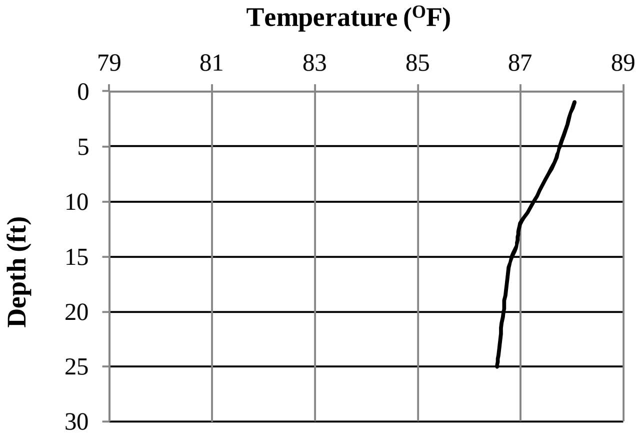
VP6-6

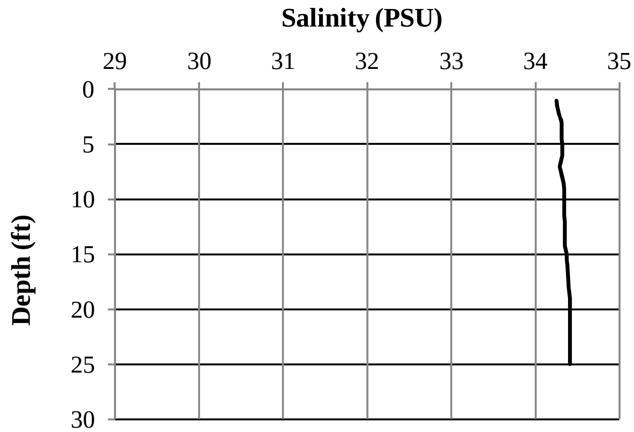




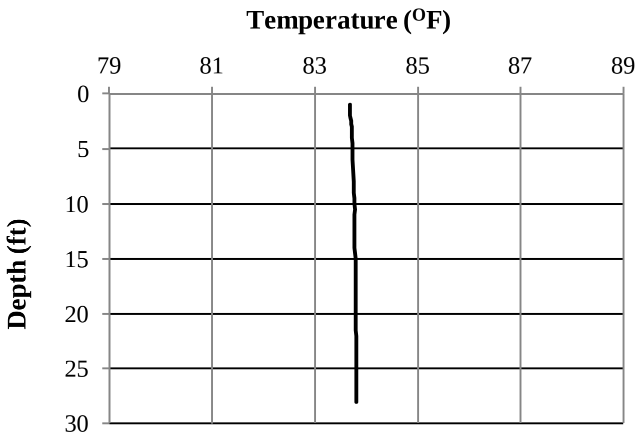
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #7
8 August 2012

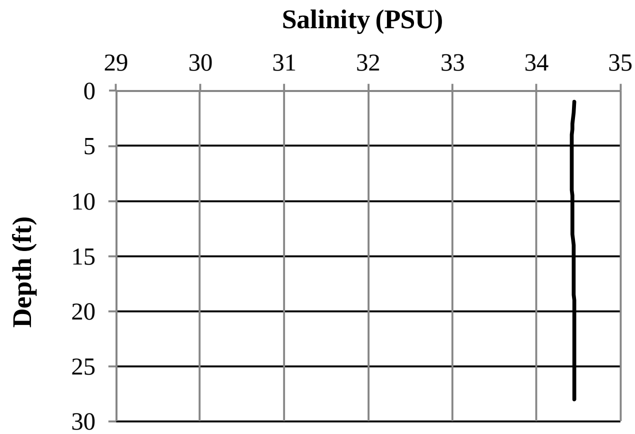
VP7-1



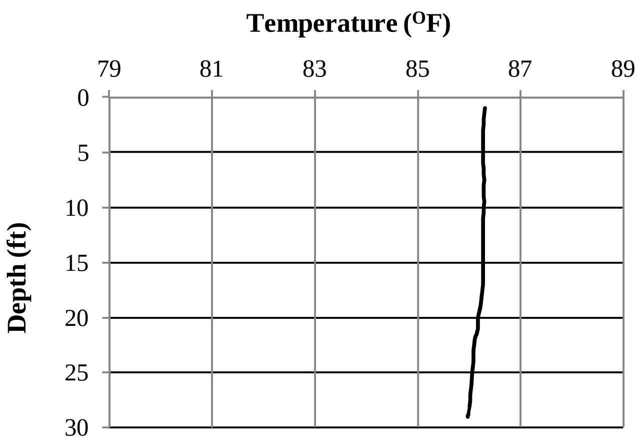


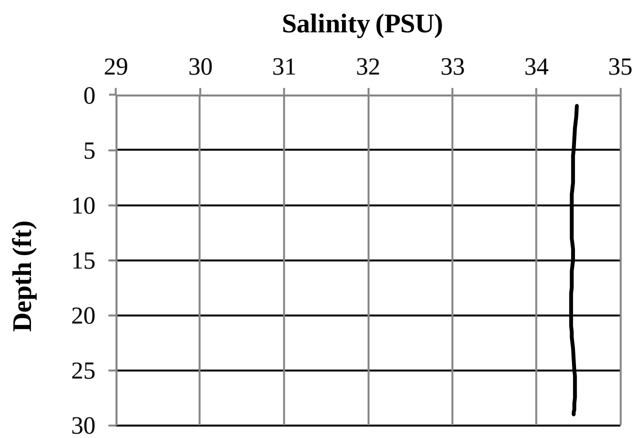
VP7-2





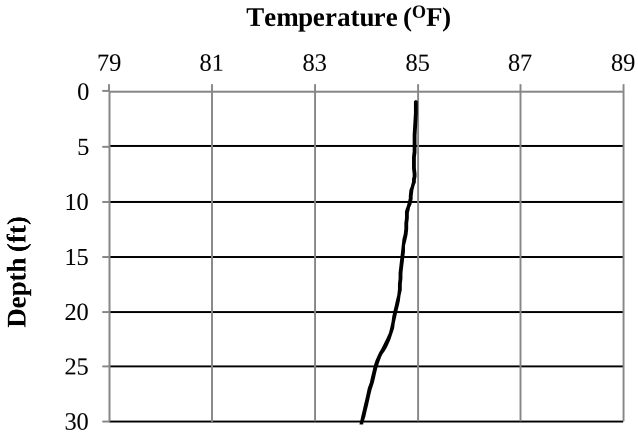
VP7-3

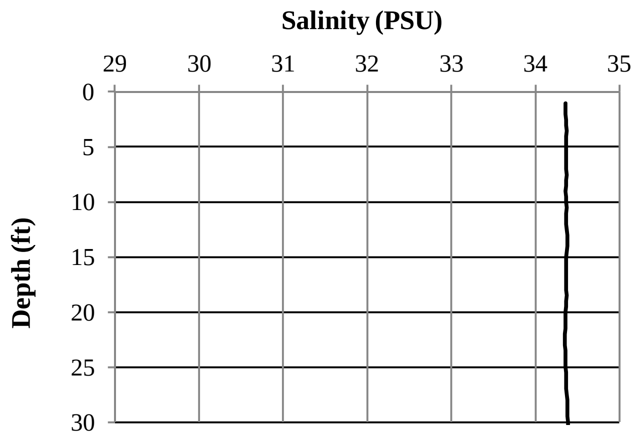




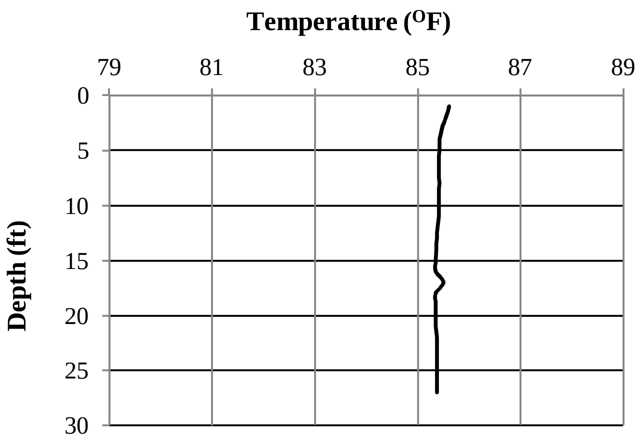
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #7
8 August 2012

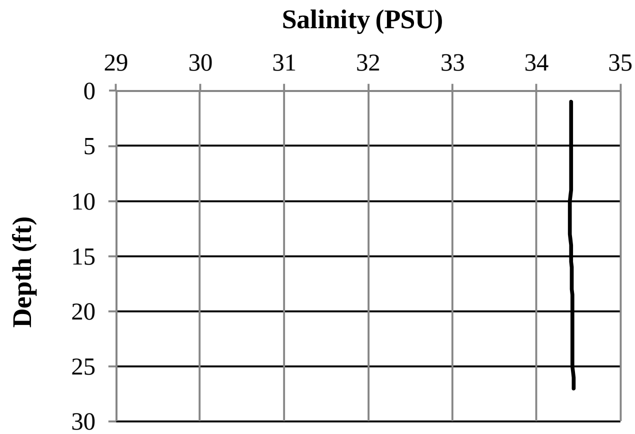
VP7-4



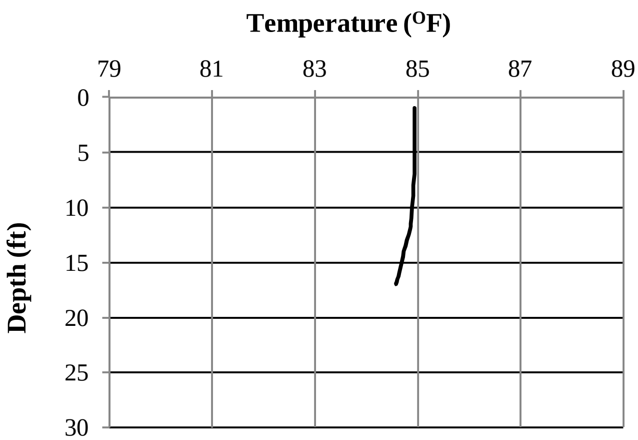


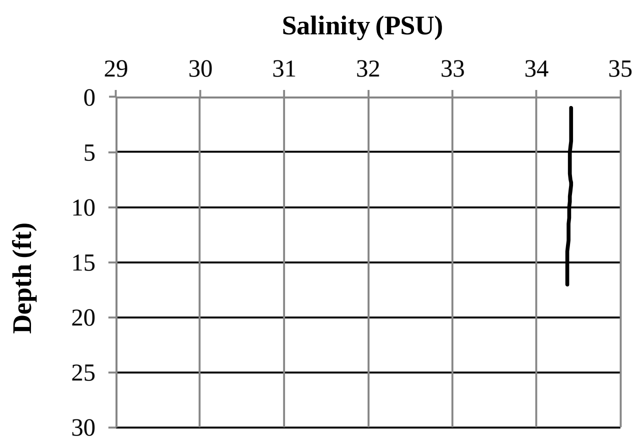
VP7-5





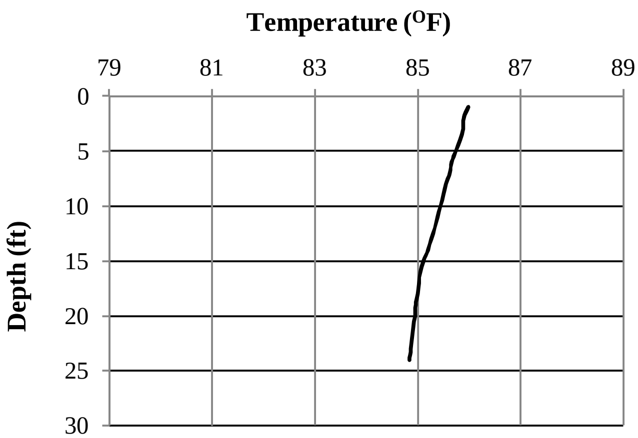
VP7-6

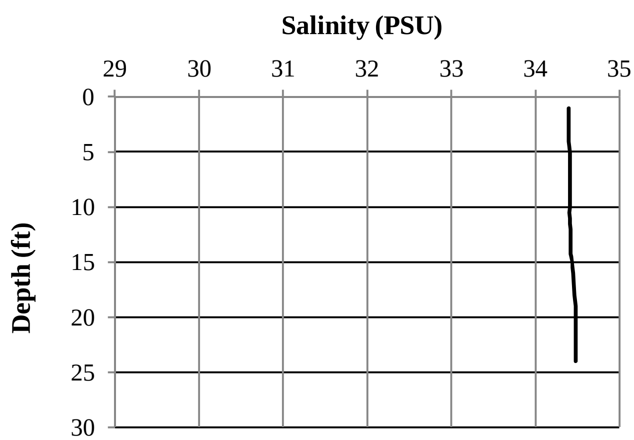




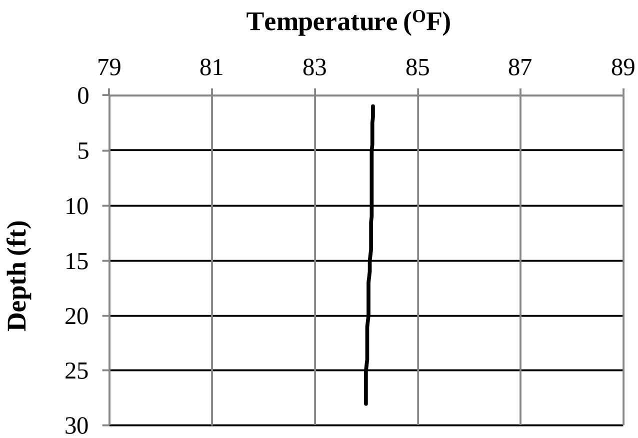
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #8
8 August 2012

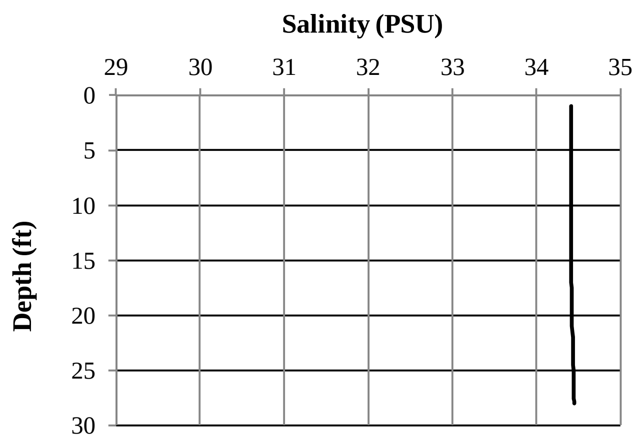
VP8-1



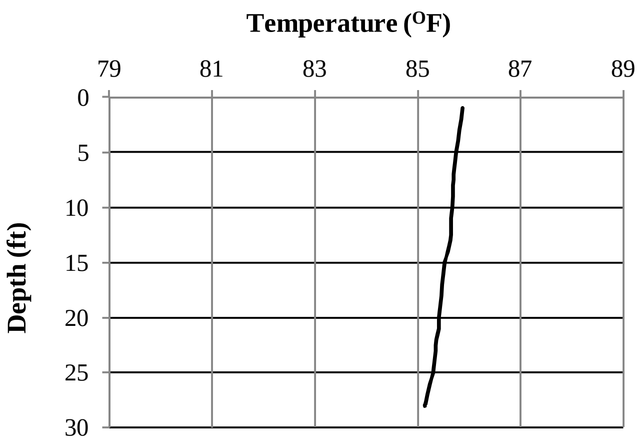


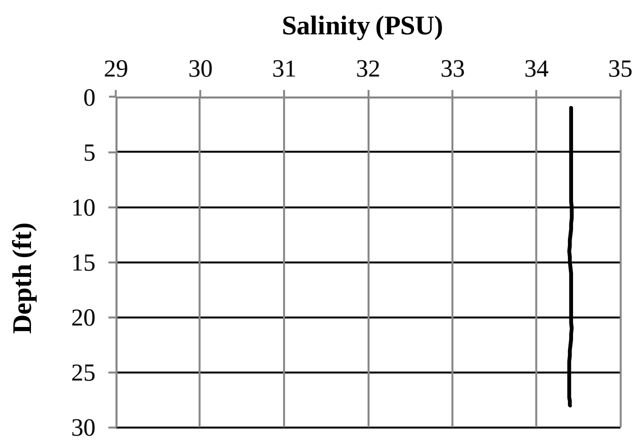
VP8-2





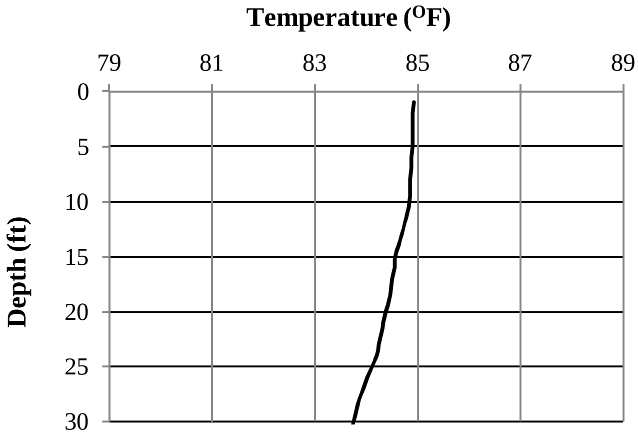
VP8-3

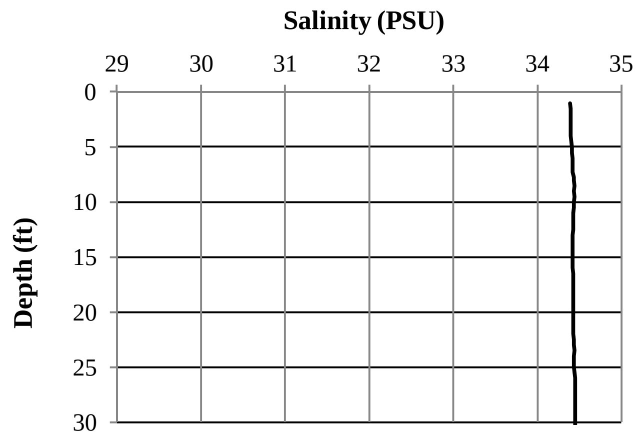




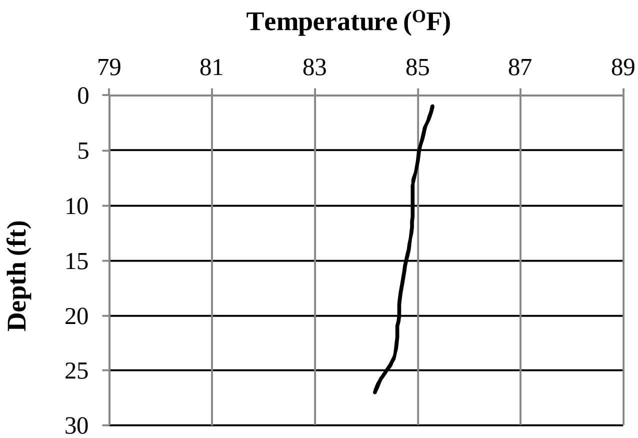
Vertical Profile Data
Thermal Plume Characterization Study
Central Aguirre, Puerto Rico
Mapping #8
8 August 2012

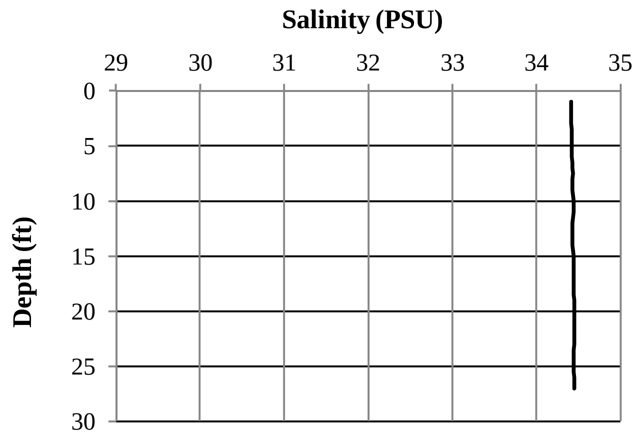
VP8-4



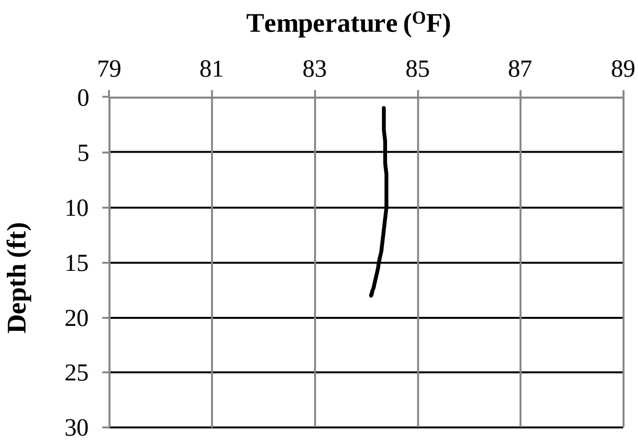


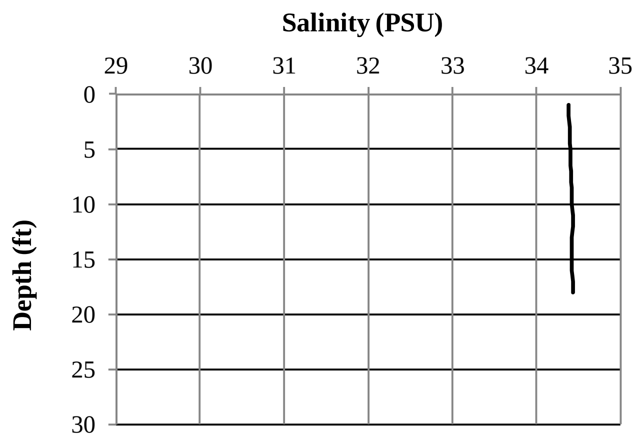
VP8-5





VP8-6





Appendix B

Quality Assurance Project Plan Dye Dilution Study

QUALITY ASSURANCE PROJECT PLAN
DYE DILUTION STUDY
PUERTO RICO ELECTRIC POWER AUTHORITY
AGUIRRE POWER PLANT COMPLEX

Prepared by
AECOM
2 Technology Park Drive
Westford, MA 01886

Prepared for
Puerto Rico Electric Power Authority
San Juan, Puerto Rico

Document Number: 60212039.100

Approvals:

PREPA Project Manager	Date
	March 30, 2011
AECOM Project Manager	Date
AECOM Quality Assurance Officer	Date
EQB Project Manager	Date
EQB Quality Assurance Officer	Date
OSI Project Manager	Date

CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

DISTRIBUTION LIST

Ms. Stephanie Wilson, AECOM Project Manager
AECOM
2 Technology Park Drive
Westford, MA 01886
(978)-589-3418Fax (978)-589-3035
Email: stephanie.wilson@aecom.com

Mr. Donald Kretchmer, AECOM Senior Technical Specialist
AECOM
45 Red Brook Circle
Wolfeboro, NH 03894
(603) 528-8918
Email: donald.kretchmer@aecom.com

Ms. Debra Simmons, AECOM QA Officer
AECOM
2 Technology Park Drive
Westford, MA 01886
(978)-589-3358 Fax (978)-589-3100
Email: debra.mcgrath@aecom.com

Mr. Kenneth Cadmus, OSI Project Manager
Ocean Surveys, Inc.
129 Mill Rock Road East
Old Saybrook, CT 06475
(860) 388-4631 Ext. 126
Fax: 860-388-5879
Email: kac@oceansurveys.com

Jaime Plaza Velazquez, PREPA Project Manager
Puerto Rico Power Authority
P.O. Box 364267
San Juan, PR 00936-4267
(787)-289-4960 Fax (787)-289-4999
ja-plaza@prepa.com

Ruperto Berrios, PREPA Water Quality Manager
Puerto Rico Power Authority
P.O. Box 364267
San Juan, PR 00936-4267
(787)-289-4966 Fax (787)-289-4999
r-berrios@prepa.com

Eng. Annette Feliberty, EQB Chief
Environmental Quality Board
Section 11488
San Juan, PR 00910
(787) 767-8181 Fax: (787) 767-4861

Carl-Axel P. Soderberg, Chief
Caribbean Environmental Protection Agency
Europa Bld., Suite 205-B
1492 Ponce de León Ave.
San Juan, PR 00907-4127

1.0 PROJECT DESCRIPTION

1.1 Introduction

The Environmental Quality Board (EQB) of Puerto Rico authorized an Interim Mixing Zone (IMZ) for Outfall 001 at the Aguirre Power Plant Complex (APPC), pursuant to the Puerto Rico Water Quality Standards Regulation (PRWQSR, 2010); specified in the National Pollutant Discharge Elimination System (NPDES) permit effective January 1, 2011. Condition 23 of the permit requires the implementation of a one year monitoring program to obtain the necessary data to validate the IMZ. The monitoring program shall consist of temperature monitoring at the boundaries of the IMZ and at the Outfall 001 to verify compliance with the applicable provisions of the NPDES permit limits and two dye studies to validate the mathematical model (Washington Group 2005) used to determine the critical initial dilution and verify the behavior of the plume within the mixing zone. This Quality Assurance Project Plan (QAPP) presents the organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with the requested dye dilution studies, as well as an alternative thermal plume mapping study, to validate the interim mixing zone of Outfall 001 at APPC. The details of the temperature monitoring study are provided in a separate QAPP. Specific protocols for field activities, equipment calibration and maintenance, and data analyses are described. Standard Operating Procedures (SOPs) for the dye study and thermal plume study have also been included as appendices to this document. All QA/QC procedures are structured in accordance with applicable technical standards and with the United States Environmental Protection Agency's (U.S. EPA) requirements, regulations, guidance, and technical standards. This QAPP has been prepared in accordance with the U.S. EPA Quality Assurance Project Plan guidance, as presented in *U.S. EPA Requirements for Quality Assurance Project Plans* (U.S. EPA March 2001) and U.S. EPA Region 2 Guidance for the Development of Quality Assurance Project Plan for Environmental Monitoring Projects (April 2004).

1.2 Background

1.2.1 Facility Description

The APPC is located on the south coast of Puerto Rico within the municipality of Salinas, on the northwest shoreline of Bahia de Jobos (Jobos Bay) (Figure 1-1). Jobos Bay is formed by Punta Pozuelo, protruding from the east, and a series of islands (cays) on the south (Cayos Caribes) and southwesterly sides (Cayos de Barca). Water depths range from 2 to 20 feet throughout most of the bay. A maximum depth of 27 feet is maintained in the dredged ship channel with naturally occurring depths of 28- 34 feet in the western bay.

The APPC consists of two 20 megawatt (MW) oil-distillate-fired gas turbine generator power packs, two 300 MW combined-cycle distillate-fired units, and two oil-fired 450 MW steam-electric units. The APPC employs a once-through cooling system utilizing ocean water withdrawn via an intake structure located along the northwest shoreline of Jobos Bay. A total of four (4) circulating water pumps (plus one spare), convey a total of 452,500 gallons per minute (gpm), or approximately 226,250 gpm per generating unit.

Heated cooling water flows from the steam-electric units into an open discharge channel.
At the end of the discharge channel, seven pumps, (six operating; one spare) each with a design capacity of 106.6 million gallons per day (MGD), conveys water to Outfall 001 at a maximum rate of 639.6 MGD (444,167 gpm). The discharge pumps convey the cooling water into a 5,800 foot long, 13 foot inside diameter, circular pipe. The discharge port at the end of the pipe is a 10-foot restrictor that discharges into Jobos Bay, east of Punta Colchones. The discharge velocity at the port is calculated to be approximately 12 feet per second (fps) at full load.

The discharge temperature at the outfall is dependent on the inflow temperature and the condenser temperature rise (CTR). The theoretical maximum discharge temperature based on the maximum CTR and a maximum ambient water intake temperature of 88.7°F (31.5°C) is 106°F (41.1°C). PREPA monitors the discharge temperature from the Aguirre Power Plant 001 Outfall daily.

1.2.2 Regulatory Status

There are presently no nationally applicable standards for thermal discharges from steam electric power plants. U.S. EPA has the authority to establish those standards on a case-by-case basis taking into account the factors enumerated in Section 306 of the Clean Water Act (CWA). Further, Section 316(a) of the CWA provides the permit applicant the opportunity to demonstrate that their proposed effluent controls are appropriate "to assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife". Current PRWQS (Section 1303.1 (D)) , states that “except by natural causes, no heat may be added to the waters of Puerto Rico, which would cause the temperature of any site to exceed 90°F (32.2°C)” and that “no thermal discharge or combination of thermal discharges into or onto the surface, estuarine and coastal waters shall be injurious to aquatic life or the culture or propagation of a balanced indigenous population there of nor in anyway affect the designated uses" (PRWQS 2010).

The APPC discharge was designed to comply with the thermal standards promulgated by EQB in 1974 to minimize the impact that the discharge may have on the Jobos Bay environment. The plant discharges heated cooling water from Outfall 001 at temperatures that sometimes exceed the PRWQS for temperature. As a result, PREPA requested under Section 316(a) of the CWA an alternate thermal effluent limitation for the Aguirre Power Plant Outfall 001. PREPA, in coordination with U.S. EPA, developed a study to determine the impact of the power plant on the ecosystem of Jobos Bay. This study formed the basis of a request for alternate thermal effluent limitations and the results were documented in a 316 Demonstration Report (Washington Group 2005). The results of the 316 Demonstration indicated that the thermal limitations under Puerto Rico water quality regulations were more stringent than necessary to protect the balanced, indigenous population of shellfish, fish and wildlife in and on the receiving waterbody. As a result of the findings of the 316 Demonstration, U.S. EPA issued PREPA a NPDES permit for APPC, effective January 1, 2011, with a defined daily maximum discharge temperature limitation at Outfall 001 of 106°F (41.1°C). The permit also defines a daily maximum temperature limitation 90°F (32.2°C) at the edge of the IMZ.

The establishment of an IMZ is authorized under PRWQS Section 1305 and is valid for a "period not to exceed one and a half years; or until the NPDES permit expires; or a date which the Board determines….whichever comes first" (EQB 2010). Condition 23(m) of the current NPDES permit requires the implementation of a one year monitoring program to obtain the necessary data to validate the IMZ. The monitoring program shall consist of temperature monitoring to verify compliance with the applicable provisions of the NPDES permit limits and a two dye studies to validate the mathematical model used to determine the critical initial dilution and verify the behavior of the plume within the mixing zone.

According to PRWQS Section 1305.9 (EQB 2010), final authorization of a mixing zone requires calibration and validation of the mathematical models used to define the IMZ. Validation of the mathematical model requires the following:

- Implementation of a one year monitoring program to validate the mathematical model during two seasons (winter and summer)

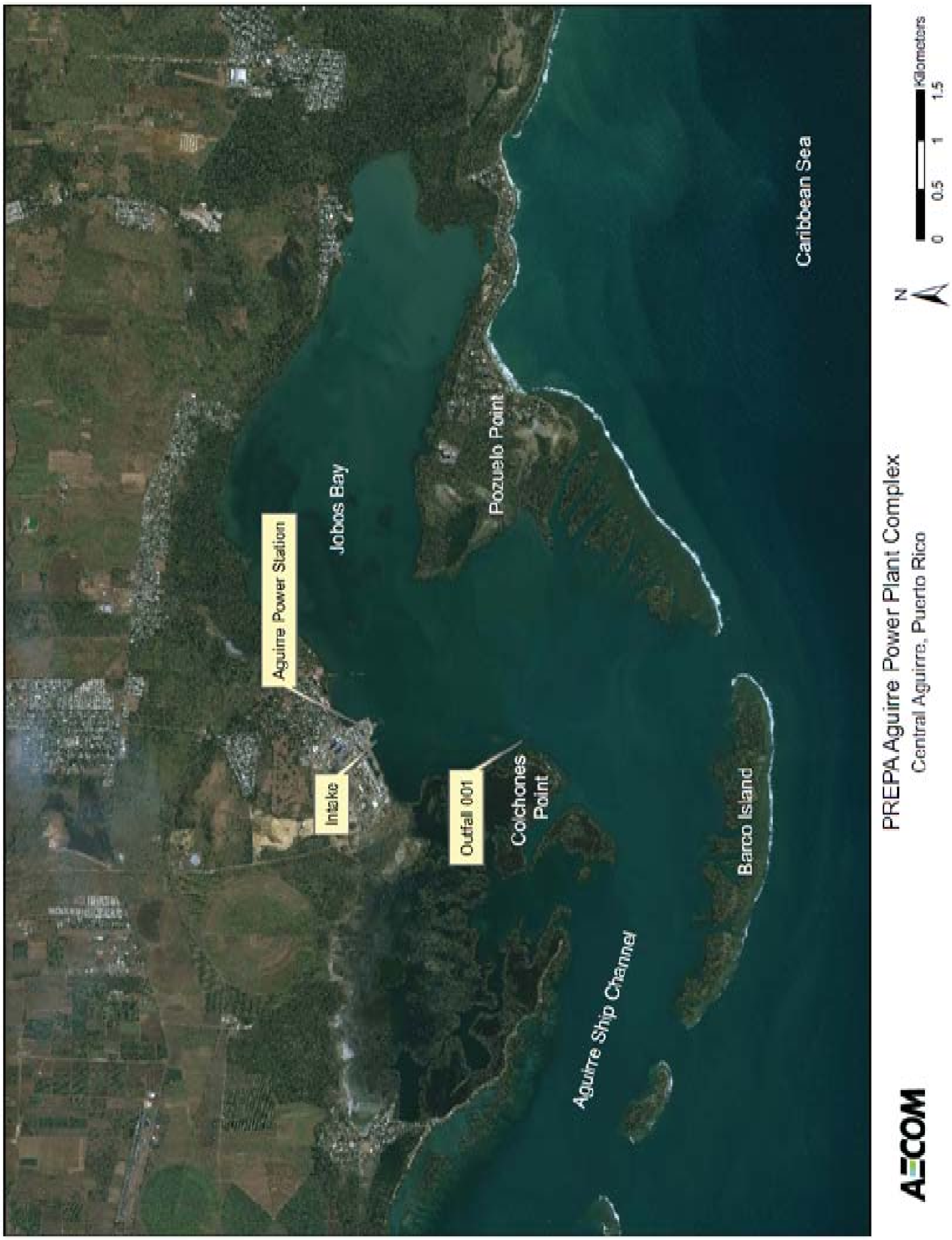
- Comparative analysis between the measured values in the sampling program and the values calculated by the model for corresponding points throughout the periphery of the mixing zone.

The model in which 90 percent of the calculated values are equal or less than the ones obtained through the sampling program shall be validated.

Although Condition 23 of the 2010 NPDES permit requires the performance of a dye study, PREPA is alternatively proposing to conduct a thermal plume mapping study to validate the mathematical model used to determine the critical initial dilution, and verify the behavior of the plume within the mixing zone, according to Section 1305.9 of the PRWQS (2010). While both a dye study and a thermal plume study can produce the required data to validate the mathematical thermal model, according to PRWQS Section 1305.9, the thermal plume study would collect temperature data that are directly comparable to the results of the mathematical thermal model. In addition, specific tide, ambient temperature, and discharge conditions can be targeted by the thermal plume study to mimic the modeled scenarios. On the other hand, the dye study can be used to determine the temperature and dilution of the discharge plume, when combined with assumptions related to the thermal transfer between the plume and ambient water. However, the amount of dye required for a discharge the size of APPC (652 MGD) is large. As a result, PREPA believes that the thermal plume study may be more appropriate as it will provide the necessary data to validate the mathematical model used to define the IMZ in a more direct and effective manner than the dye study.

This QAPP presents the objectives, planned activities, and specific QA/QC procedures associated with the requested dye dilution studies, as well as the proposed alternative thermal plume mapping study. Both the dye study and the proposed alternative thermal plume mapping study are being detailed for EQB to evaluate and determine the preferred method to validate the mathematical models used to define the IMZ.

Figure 1-1 Jobos Bay



1.3 Objectives and Scope

The objectives of the dye study and/or thermal plume study are to validate the mathematical model used to establish the IMZ by:

- Determining the critical initial dilution of the Outfall 001 discharge and
- Verifying the behavior of the discharge within the mixing zone.

The elements of the data collection program are summarized in Table 1-1. Data collected from this program will be used to validate the mathematical model used to establish the IMZ of Outfall 001 at APPC.

Table 1-1 Summary of Data Collection Program

Methods	No. of Sampling Events/Yr	No. of Sampling Events/ 24 Hour Period	No. of Stations/Sampling Event	Depth (ft)
Dye Dilution Study	2 (summer & winter)	4	Multiple transects	1 ft below surface and vertical profiles
Thermal Plume Study (alternative option)	2 (summer & winter)			
a) Temperature moorings		Continuous (6 min intervals)	5 moorings (1 at discharge and 4 in a "T" formation at 500-fot spacing	a1) 1 ft below surface a2) Mid depth a3) 1 ft above bottom
b) Plume mapping		4	Multiple transects	1 ft below surface and vertical profiles

Notes: Four sampling events per 24 hour period corresponding to high slack, maximum ebb, low slack and maximum flood tides

1.4 Technical Approach

Detailed data collection procedures are described in Section 4.0. SOPs for data collection and analysis are also provided in Appendix A.

1.4.1 Dye Dilution Study

The dye dilution study is being proposed to measure the transport and dilution of the Outfall 001 discharge into Jobos Bay through injection of Rhodamine WT fluorescent dye into the discharge at a controlled rate, monitoring the concentration of dye within the intake and discharge water, and mapping the horizontal and vertical distribution of the resultant dye plume using a calibrated fluorometer. The dye study will be conducted according to the procedures described in SOP OSI-D-1. As indicated in Table 1-1, sampling will be conducted during the summer and winter season, concurrent with two of the four required temperature monitoring survey events.

The components of the dye study include dye injection, initial concentration and recirculation stations within the power plant, along with four boat-based mappings of dye concentrations both horizontally and vertically, covering a complete tidal cycle. Because the primary focus of the dye study will be document the initial zone of dilution from the discharge, dye concentrations will be mapped to a concentration of 1% or 3,000 feet from the diffuser. The data collected in this study will be used to determine the initial dilution and verify the behavior of the plume within the mixing zone. The data from the dye study may also be used to determine the dilution of the discharge plume, which when combined with assumptions related to the thermal transfer between the plume and ambient water, can be used to approximate temperature.

1.4.2 Thermal Plume Study

The thermal plume study is being proposed to measure the thermal plume from Outfall 001 into Jobos Bay directly. The thermal plume study will be conducted according to the procedures described in SOP OSI-T-1. Thermal plume characteristics will be recorded through both temperature moorings and real-time boat-based transect surveys. As indicated in Table 1-1, sampling will be conducted during the summer and winter season, concurrent with two of the four required temperature monitoring survey events.

In-situ temperature moorings will be deployed near the mouth of the discharge. One mooring will be placed directly in front of the discharge while four more moorings will be placed in a "T" formation at 500 foot spacing from the discharge. Each mooring will consist of three recording thermistors placed at one foot below the surface, mid depth and one foot above the bottom. One thermistor will also be deployed near the head of the plant's discharge pipe, if possible, to record initial conditions.

A thermal mapping program will also be conducted to document the horizontal and vertical temperature plumes being discharged from Outfall 001, covering a complete tidal cycle. Each mapping will be completed over approximately a two hour time span every six hours over a 24 hour period to coincide with diurnal tidal conditions. A bundled set of two thermistors will be deployed from the survey vessel at a depth of one foot below the water surface to map the horizontal temperature structure. The vertical temperature and density structure of the water column will be documented throughout each mapping using a Sea-Bird SBE-19 SeaCat Profiler for vertical temperature and conductivity measurements. Because the primary focus of the thermal plume study will be to document the initial zone of dilution from the discharge, transects will be focused on an area within 3,000 feet of the discharge. The data collected in this study will be used to validate the IMZ and verify the behavior of the plume within the mixing zone.

1.5 Schedule of Activities and Deliverables

According to the conditions of the NPDES permit, the dye study and/or thermal plume study shall be conducted twice over the course of a year in coordination with the temperature monitoring study, with one event occurring during the summer and one event during the winter. The first study (summer) shall be initiated 90 days following EQB approval of this Plan. The second study will be initiated the following winter. Results of each study will be summarized in a brief survey report, to be submitted within 90 days of completion of the field work. This report will include a schedule of operations, data collection and processing procedures, graphics and all datasets.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 Organization and Responsibilities

PREPA has oversight responsibility for all phases of the study. PREPA's primary contractor, AECOM, will oversee the field investigation and will prepare the report. Project management will also be provided by AECOM. The various management, QA, field, and data analysis responsibilities of key project personnel are defined below. Figure 2-1 presents the lines of authority and communication specific to this study.

2.1.1 Management Responsibilities

PREPA Project Manager

The PREPA Project Manager is primarily responsible for project direction and decisions concerning technical issues and strategies, setting the basic program policies applicable to work assignments, and oversight of the Contractor. The PREPA Project Manager and/or his designee will communicate directly with the EQB and will provide the major point of contact and control for matters concerning the project.

AECOM Project Manager

The AECOM Project Manager has responsibility for technical, financial, and scheduling matters and will serve as the main contact with PREPA. Other duties, as necessary, include

- Assuring adherence to QAPP and obtaining approvals for any changes to the QAPP,
- Assignment of duties to project staff and orientation of the staff to the specific needs and requirements of the project,
- Approval of project-specific procedures and internally prepared plans, drawings, and reports, and
- Maintenance of the project file.

AECOM Senior Technical Specialist

- Development and review of QAPP,
- Subcontractor procurement, and
- Coordination of all field and laboratory task activities, communications, reports, and technical reviews, and other support functions, and facilitating study activities with the technical requirements of the project.

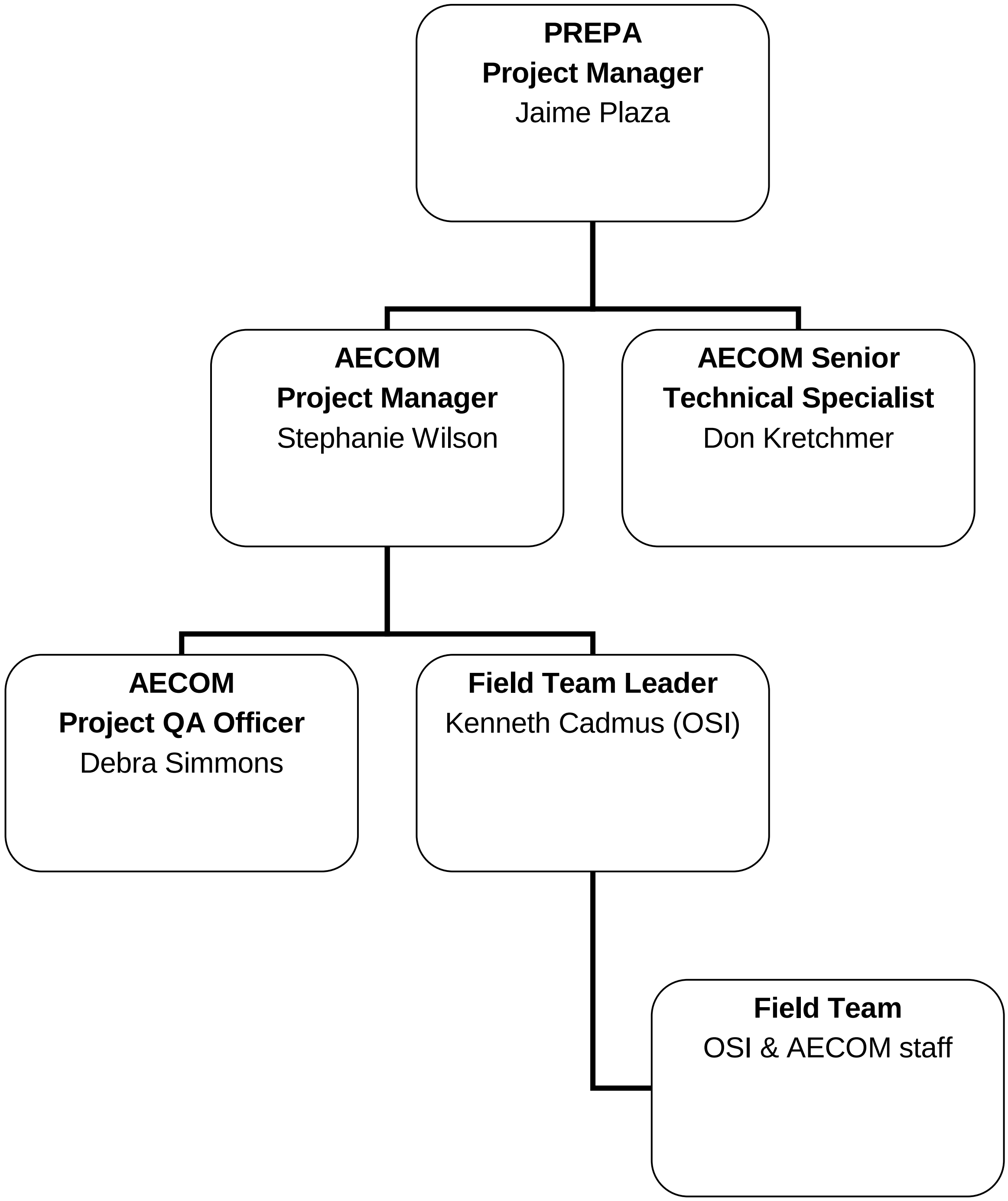
2.1.2 Quality Assurance Responsibilities

AECOM Project QA Officer

The AECOM Project QA Officer has overall responsibility for quality assurance oversight. The AECOM Project QA Officer communicates directly to the AECOM Project Manager. Specific responsibilities include:

- Reviewing and approving the QAPP,
- Reviewing and approving QA procedures, including any modifications to existing approved procedures,
- Ensuring that QA audits of the various phases of the project are conducted as required,
- Providing QA technical assistance to project staff,
- Ensuring that data validation/data assessment is conducted in accordance with the QAPP, and
- Reporting on the adequacy, status, and effectiveness of the QA program to the AECOM Project Manager.

Figure 2-1 Study Organization



2.1.3 Field Responsibilities

AECOM will subcontract with Ocean Surveys, Inc. to lead the field effort.

Field Team Leader (FTL)

The FTL has overall responsibility for completion of all field activities in accordance with the QAPP and is the communication link between Contractor project management and the field team. Specific responsibilities of the FTL include:

- Understanding and directing the implementation of the QAPP,
- Coordinating activities in the field,
- Assigning specific duties to field team members,
- Mobilizing and demobilizing of the field team and subcontractors to and from the site,
- Resolving any logistical problems that could potentially hinder field activities, such as equipment malfunctions or availability, personnel conflicts, or weather dependent working conditions,
- Implementing field QC including issuance and tracking of measurement and test equipment and control and collection of all field documentation,
- Determining if a sample location must be moved and if so, communicating this decision to the appropriate personnel, including the Contractor Project Manager, and ensuring that the action and the basis for it is appropriately documented,
- Communicating any nonconformance or potential data quality issues to the AECOM Project Manager in a timely manner, and
- Assisting with report preparation.

Field Staff

The field staff reports directly to the FTL and will consist of trained OSI and AECOM scientists. The responsibilities of the field team include:

- Understanding and implementing the QAPP as it relate to their duties,
- Collecting field measurements according to documented procedures in the QAPP and the field SOPs (Appendix A),
- Ensuring that field instruments are properly operated, calibrated, and maintained, and that adequate documentation is kept for all instruments,
- Ensuring that field documentation and data are complete and accurate, and
- Communicating any nonconformance or potential data quality issues to the FTL in a timely manner.

2.2 Training

2.2.1 Specialized Training

The field sampling portion of the project does not include project-specific or non-routine field sampling techniques, therefore specialized training is not required. However, prior to starting work, personnel will be given instruction specific to the project, covering the following areas:

- Organization and lines of communication and authority,
- Overview of the QAPP,
- QA/QC requirements,
- Documentation requirements, and
- Health and safety requirements.

3.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

The overall QA objective for this study is to develop and implement procedures for field sampling, data analysis, and reporting that will provide valid results that are defensible. This section will provide the specific project objectives and intended data usages for the project. Specific procedures for sampling, data analysis, reporting of data, internal QC, audits, preventive maintenance of field equipment, and corrective action are described in other sections of this QAPP.

3.1 Precision

3.1.1 Definition

Precision is a measure of the degree to which two or more measurements of the same entity are in agreement.

3.1.2 Precision Objectives

Field precision is typically assessed through the collection and measurement of field duplicates and triplicates. The majority of variation typically observed in dye concentrations and temperature measurements is driven primarily by variation in environmental patterns, including tidal cycle, water circulation, and weather patterns; and plant operations. Thus variability resulting from sampling and/or analytical procedures is not likely to be significant. Therefore, identifying a level of acceptable variation among field duplicates is not appropriate.

3.2 Accuracy

3.2.1 Definition

Accuracy is the degree of agreement between the observed value and an accepted reference or true value.

3.2.2 Accuracy Objectives

Accuracy in the field is achieved through the adherence to all instrument calibration requirements and SOPs.

3.3 Representativeness

3.3.1 Definition

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition within a defined spatial and/or temporal boundary.

Representativeness will be achieved by ensuring that the QAPP is followed and that proper SOPs are used.

3.3.2 Measures to Ensure Representativeness of Data

The objective of this program is to validate the IMZ of Outfall 001 at APPC. Studies will be conducted during the summer and winter, over a complete tidal cycle, in order to provide sufficient data to allow for seasonal characterization of the IMZ under diurnal tidal conditions.

Dye concentrations and/or temperature measurements will be mapped both horizontally and vertically along transects run perpendicular to the flow of the discharge plume. Continuous dye concentrations and/or temperature measurements will be collected at one foot below the water surface. In situ temperature moorings will also be deployed around the mouth the Outfall 001 discharge, with data loggers positioned at one foot below the surface, mid depth and one foot above the bottom.

Because the primary focus of the study is to document the initial zone of dilution from the discharge, dye concentration readings and/or temperature measurements will be focused on an area within 3,000 feet of the discharge.

3.4 Completeness

3.4.1 Definition

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. "Normal conditions" are defined as the conditions expected if the sampling plan was implemented as planned.

3.4.2 Completeness Objectives

Field completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. The field completeness objective is greater than 90 percent.

3.5 Comparability

3.5.1 Definition

Comparability expresses the confidence with which one data set can be compared to another.

3.5.2 Measures to Ensure Comparability

Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the QAPP is followed and that proper sampling techniques and analysis are used. Standard techniques, as described in the SOP's presented in Appendix A, will be used for the duration of the project.

4.0 DATA COLLECTION PROCEDURES

4.1 Collection and Measurement Procedures

This section provides summaries of the methods and procedures used for instrument calibration, field measurements, and data processing. Additional details are provided in the SOPs in Appendix A.

4.1.1 Navigation and Sample Positioning

All navigation will be performed and sampling locations will be recorded using a differential global positioning system (DGPS) – with accuracy of approximately 1 meter – along with line-of-sight location confirmation. The location of sampling transects will be established by recording the start and end positions of each transect. All positioning data will be referenced to the Puerto Rico State Plane-North America Datum 1983 (NAD83), in feet.

4.1.2 Dye Dilution Study

The transport and dilution of the plant's discharge into Jobos Bay will be determined by injecting Rhodamine WT dye into the discharge at a controlled rate, monitoring the concentration of dye within the intake and discharge water, and mapping the horizontal and vertical distribution of the resultant dye plume within 3,000 feet of the discharge.

Rhodamine WT is a fluorescent, water soluble, biodegradable tracer which can be accurately measured in extremely low concentrations, typically less than 0.1 parts per billion (ppb). A 20% aqueous solution of Rhodamine WT will be injected near the head of the plant's discharge using a Masterflex L/S Computerized Drive laboratory pump. Given an average flow of 652 MGD, the Rhodamine WT will be injected at a rate of 11.3 lb/hr; this rate should be sufficient to produce a discharge concentration of approximately 10 parts per billion (ppb). Assuming a discharge concentration of 10 ppb and a practical dye detection limit of 0.1 ppb above background, the field team will be able to accurately record the dye concentrations to a point where it has been diluted in excess of 100:1 (1%).

The dye injection will be initiated 6- 8 hrs prior to plume mappings to ensure a sufficient plume has been generated within the discharge's nearfield zone. Although it is not anticipated, some quenching of the Rhodamine WT dye may occur due to any material or chemical present in the discharge flow. A “recover test” will be conducted where a known quantity of discharge water is tagged with dye and monitored for fluorescence periodically throughout the study to quantify any changes in dye concentration and apply those changes to the data during data processing.

A Turner Designs Model 10AU fluorometer, fitted with a flow through sample chamber, will be used to monitor the in situ dye concentration of the discharge and intake in real-time. The actual location of the measurements will be determined by the field crew after evaluation of the plant’s configuration. At each location, OSI will setup portable self-contained sampling stations. The initial concentration station will be placed at a point with sufficient distance from the dye injection station to allow complete mixing of the dye. The fluorometer and computer setup will record continuously throughout the study to document initial dye concentrations.

The plume created from the discharge will be documented four times corresponding to high slack, maximum ebb, low slack, and maximum flood tides. Each mapping will be completed over approximately a two hour time span every 6 hours over a 24 hour period to coincide with the diurnal tidal conditions. The survey vessel will be equipped with an electronic positioning system and onboard fluorometer system. The plume will be mapped both horizontally and vertically along transects run perpendicular the flow of the plume. Due to the changing of the tide, transects may be adjusted on a per mapping basis to best characterize the plume. Dye concentration will be collected continuously at a fixed depth of 1 foot along each transects with a line spacing that will gradually increase away from the diffuser. The plume will be mapped to a concentration of 1% or 3,000 feet from the diffuser, whichever comes first. Vertical profiles will be completed periodically along the centerline of the plume. Also, one transect and vertical profile will be completed prior to dye injection to document background conditions.

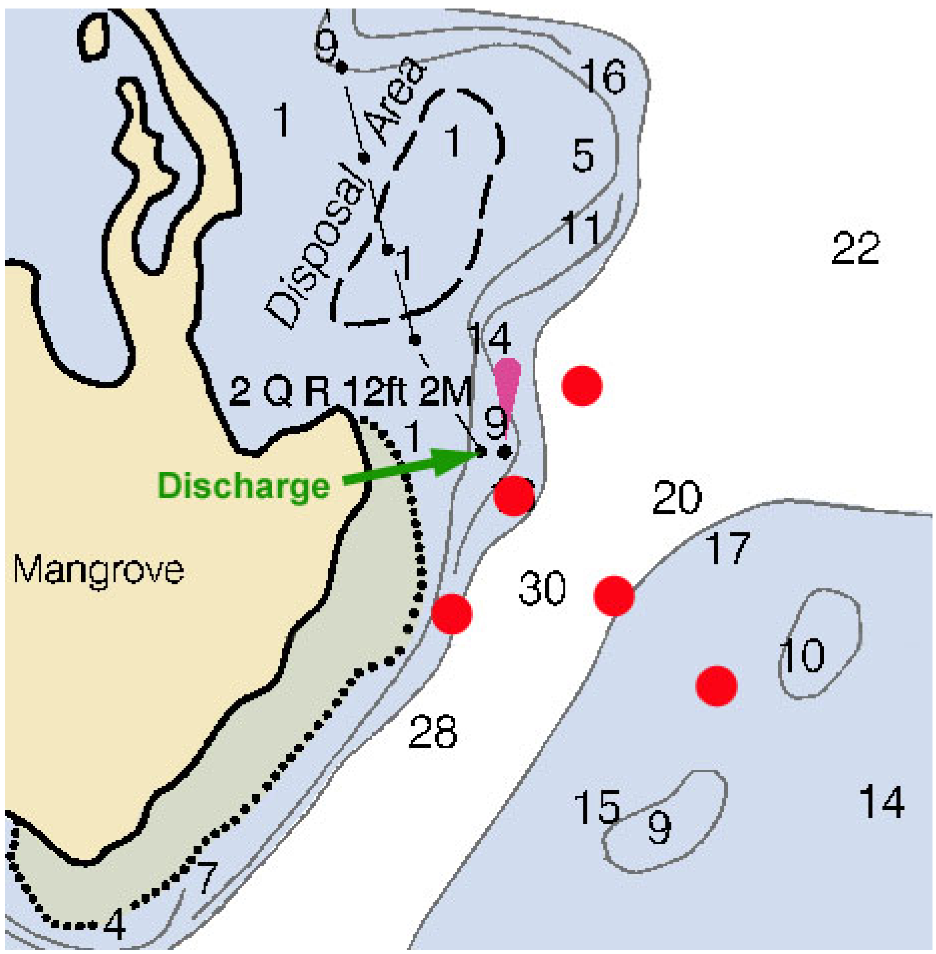
4.1.3 Thermal Plume Mapping

The thermal plume characterization study is designed to characterize the thermal plume from the Outfall 001 discharge through both deployed temperature moorings and real-time boat-based transect surveys.

Temperature Moorings

In situ temperature moorings will be deployed for a period of two days to encompass the real-time thermal mappings surveys. A total of five temperature moorings will be deployed near the mouth of the discharge in Jobos Bay. One mooring will be placed directly in front of the discharge while the remaining four moorings will be placed in a "T" formation at 500 foot spacing (Figure 4-1). Each mooring will consist of three Onset Hobo Water Temperature Pro v2 data loggers positioned at one foot below the surface, mid depth, and one foot above the bottom. The instruments will all be set to record at 6-minute intervals to correspond to the NOAA tidal datasets. All temperature loggers will be cross-calibrated in a temperature bath prior to deployment to maximize instrument accuracy. In addition, one temperature sensor will be deployed near the head of the plant's discharge pipe to record initial conditions, if possible.

Figure 4-1 Temperature Mooring Layout



Thermal Mappings

A thermal mapping program will be complete over a complete tidal cycle to document the horizontal and vertical temperature plumes associated with discharge from Outfall 001. Four mappings will be conducted coinciding with maximum flood, high slack, maximum ebb and low stack tidal periods.

Temperature data will be collected along a series of transects across the existing plume structure. The horizontal temperature distribution will be acquired using a thermal monitoring system interfaced to a DGPS navigational software system aboard the survey vessel. The thermal monitoring system consists of a central processing unit with hard wire thermistor inputs. The thermistor inputs consist of YSI Model 44036 Series epoxy encapsulated thermistor probes with a temperature range of -112ºF to 167ºF and an accuracy of ±-0.1ºF for the full range. A bundled set of two thermistors will be deployed for backup and redundancy. The probes will be located on the side of the survey vessel, directly under the DGPS antenna, at a depth of one foot below the surface of the water. Data from the thermistors will be uploaded at 2 Hz into the navigational computer system and combined with the x and y positioning data. A minimum of 10 lines (typically 10-15 lines) will be completed over each tidal cycle.

The vertical temperature and density structure of the water column will also be documented throughout each mapping using a Sea-Bird SBE-19 SeaCat Profiler for vertical temperature and conductivity measurements. The SeaCat profiler is a self-powered, self-contained micro processing unit capable of collecting temperature, conductivity and depth data at a rate of two scans per second. Profiles will be collected at selected sites on each transect along the approximate centerline of the plume.

4.2 QC Sample Collection

QC measures for data collection include field review of data collected, verification of field measurements, and visual inspection and calibration of equipment to ensure proper working order. These procedures are described in the SOPs included as Appendix A.

5.0 CUSTODY

Custody is one of several factors that are necessary for the defensibility of environmental data. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

A sample or evidence file is considered to be under a person's custody if:

- The item is in the actual possession of a person, or
- The item is in the view of the person after being in actual possession of the person, or
- The item was in the actual physical possession of the person but is locked up to prevent tampering, and
- The item is in a designated and identified secure area.

5.1 Field Custody Procedures

Field logbooks will be used for recording the data collection activities performed during the study. As such, entries will be described in as much detail as possible so that a particular situation could be reconstructed without reliance on memory.

Field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to field personnel, but will be stored in the project files when not in use. Each logbook will be identified by the project-specific document number.

The title page of each logbook will contain the following:

- Person to whom the logbook is assigned,
- The logbook number,
- Project name and number,

- Project start date, and
- End date.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, weather, names of all field team members present, and the signature of the person making the entry will be entered.

All measurements and observations will be recorded. All entries will be made in permanent ink, signed, and dated and no erasures or obliterations will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark which is signed and dated by the sampler. Whenever a measurement is made, a detailed description of the sampling location, which includes compass and distance measurements, or, latitude and longitude information (e.g., obtained by using GPS) will be recorded. The number of photographs taken of the sampling location, if any, will be noted. All equipment used to make measurements will be identified, along with the date of calibration.

Data will be collected following the procedures documented in Section 4.0 of this QAPP and in the SOPs included in Appendix A. The equipment used to collect data will be noted, along with calibration records, the time of sampling, sample description, and depth at which the sample was collected.

5.2 Laboratory Custody Procedures

There is no analytical laboratory component to this program.

5.3 Project Files

The project file (evidence file) will be the central repository for all documents which are relevant to sampling and analysis activities as described in this QAPP. The Contractor is the custodian of the project files and will maintain the contents of the project files, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, and data reviews in a secured, limited access area and under custody of the Contractor Project Manager.

The project files will include at a minimum:

- Field logbooks,
- Field data and data deliverables,
- Photographs,
- Drawings,
- Data validation and assessment reports, and
- Progress reports, QA reports, interim project reports, etc.

6.0 CALIBRATION PROCEDURES

Field instruments will be calibrated daily according to the manufacturer's specifications. All calibration procedures performed will be documented in the field logbook and will include the date/time of calibration, name of person performing the calibration, reference standard used, temperature at which the readings were taken, and the readings.

The GPS system will be checked against a reference point with known coordinates at the start and end of each offshore sampling day.

All field fluorometers will be calibrated against dye dilution standards created from the specific manufacturer dye lot used for this study. The range of the dilution standards will exceed both minimum and maximum values to be recorded in the field. Calibration curves will be established for each individual fluorometer and will be applied during post processing.

All temperature probes and thermistors will be calibrated in a temperature bath prior to field operations. Each instrument will be subject to a variety of temperatures which will exceed both minimum and maximum values to be recorded in the field. Linear calibration curves will be established for each individual instrument and will be applied during post processing.

7.0 ANALYTICAL PROCEDURES

No analytical procedures will be conducted for the dye dilution study or the thermal plume mapping study.

8.0 INTERNAL QUALITY CONTROL CHECKS

QC procedures for field measurements will include calibrations as described in Section 6. Collection of the samples will be in accordance with the procedures described in Section 4 and at the frequency specified in Section 3 of this QAPP.

9.0 DATA REDUCTION, VERIFICATION, VALIDATION, AND REPORTING

All data generated through field activities will be reduced and validated prior to reporting.

9.1 Data Reduction

Plume mapping data (dye concentration and/or temperature) will be captured on a laptop PC using a data acquisition system that integrates the fluorometer and/or thermistor instrumentation and navigation software. All field acquired data will be reviewed for reasonableness by the FTL or designee before moving off station.

Deviations to the procedures detailed in the SOP must be recorded in the field logbook at the time of occurrence, summarized on a non-conformance report, and communicated to the Project QA Manager no later than the end of the day.

All information related to analysis will be documented in the data report. Prior to being released as final, data will proceed through a tiered review process. Data verification starts with the FTL who reviews the data to for reasonableness. The data reduction and initial verification process must ensure that:

- Data collection and analysis information is correct and complete,
- Results are correct and complete,
- The appropriate SOPs have been followed and are identified in the project records,
- Proper documentation procedures have been followed, and
- All nonconformances have been documented.

9.2 Data Verification

The procedures used to evaluate field data will include checking procedures utilized in the field, ensuring that field measurement equipment was properly calibrated, checking for transcription errors, and comparing the data to historic data or verifying its “reasonableness”. Field records will be generated and maintained to cover all aspects of collection including chronology of events, station locations, time/date, sampler name, and data collected.

9.3 Data Validation

Validation of the data by the AECOM Project Manager will include a review for completeness and scientific "reasonableness". Any anomalies or discrepancies noted during validation will be resolved as discussed in Section 13.

9.4 Data Analysis

9.4.1 Dye Dilution Study

Dye concentrations within the plant will be compiled to deliver data at one-minute intervals. In addition, dye injection rates as compared with initial concentration data will be utilized to verify plant flow conditions throughout the dye study period. Dye data from Outfall 001 and the surrounding area will be processed to deliver dye concentration and dilution data at 10-foot intervals along each transect and 1-foot vertical bins on the vertical profiles. Dye concentration data will be presented in plan view contoured drawings and vertical profiles of dye dilutions and equivalent dye concentration. Dye dilution values will be based on average initial concentration values during the extent of each dye plume mapping.

9.4.2 Thermal Plume Study

Real-time thermal plume mappings will be displayed as plan view color contoured drawings. CTD profiles will be shown as vertical profiles of temperature, salinity and density. Temperature moorings will be displayed as time series plots.

9.5 Reporting

The data resulting from each study will be presented in a data report within 90 days following completion of field activities. The data report will incorporate the following information:

- Detailed schedule of operations

- Data collection and processing procedures, including any modifications from the approved plan.

- Time series plots
  - Plant flow data
  - Dye injection,
  - Initial concentration, and/or
  - Temperature measurements

- Contoured drawings
  - Dye concentrations and/or
  - Thermal plume

- Vertical profiles
  - Dye concentration and/or
  - Temperature

- Data CD

10.0 PERFORMANCE AND SYSTEMS AUDITS

Performance and system audits of field activities are conducted to verify compliance with the procedures established in the QAPP. The audits of field activities include two independent parts: internal and external audits. Performance audits are not applicable to these studies.

10.1 Internal Audits

At the request of EQB, PREPA, or at the discretion of the AECOM Project Manager, internal system audits of field activities may be conducted and documented by the Contractor Project QA Officer. The purpose of these audits is to verify that all established procedures are being followed. The audit will include examination of field records, field measurement results, field instrument operating and calibration records, and maintenance of QA procedures. Follow-up audits will be conducted to correct deficiencies, and to verify that QA procedures are maintained throughout the investigation. An example of a field audit checklist is included as Figure 10-1.

During the audit, the Contractor Project QA Officer will keep detailed notes of audit findings. Preliminary results of the audit will be reviewed with the FTL while on site to ensure that deficiencies adversely affecting data quality are immediately identified and corrective measures initiated. Upon completion of the audit, the Contractor Project QA Officer will prepare a written audit report, which summarizes the audit findings, identifies deficiencies and recommends corrective actions. This report will be submitted to the Contractor Project Manager, who will be responsible for ensuring that corrective measures are implemented.

10.2 External Audits

External performance and system audits, if conducted, will be the responsibility of EQB.

Figure 10-1 Example of Field Audit Checklist

Project: **Site Location:** **Auditor:**	
1. Was project-specific training held?	
2. Are copies of project plans (QAPP) on site and available to personnel?	
3. Are data being collected in accordance with the project plans?	
4. Is field instrumentation being operated and calibrated in accordance with the project plans?	
5. Are field records complete, accurate, up-to-date, and in conformance to good recordkeeping procedures?	
6. Are modifications to the project plans being communicated, approved, and documented appropriately?	
Additional Comments:	
Auditor:	**Date:**

11.0 PREVENTIVE MAINTENANCE

Specific preventative maintenance procedures to be followed for field equipment are based on those recommended by the manufacturer. Field instruments will be checked for proper functioning daily before use. These checks will be documented in the field records.

Critical spare parts will be immediately available to reduce potential downtime. Spare parts to be maintained on site will be those that cannot be shipped to the site within one day and have the potential to affect the overall schedule by more than one day. Backup instruments and equipment will be available within 1-day shipment to avoid delays in the field schedule.

12.0 CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-limit QC performance that can affect data quality. Corrective action can occur during field activities, data validation, and data assessment.

12.1 Field Corrective Action

Corrective action in the field may be needed when the study area is modified (i.e., sampling area other than those specified in the QAPP), or when field procedures require modification, etc. due to unexpected conditions. The field team may identify the need for corrective action. The FTL will approve the corrective action and notify the AECOM Project Manager. The AECOM Project Manager, in consultation with the AECOM Project QA Officer, will approve the corrective measure. The FTL will ensure that the corrective measure is implemented by the field team.

If the corrective action will supplement the existing plan (e.g., additional locations) using existing and approved procedures in the QAPP, corrective action approved by the AECOM Project Manager will be documented. If corrective actions result in less measurements, alternate locations, etc., which may cause project QA objectives not to be achieved, it will be necessary that all levels of project management, including PREPA management and, possibly, the EQB, concur with the proposed action.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected due to unapproved or improper use of approved methods. The Contractor Project QA Officer will identify deficiencies and recommend corrective action to the Contractor Project Manager. Implementation of corrective actions will be performed by the FTL and field team. Corrective action will be documented in QA reports to the project management team (Section 13.0).

Corrective actions will be implemented and documented in the field record book. Documentation will include:

- A description of the circumstances that initiated the corrective action,
- The action taken in response,

- The final resolution, and
- Any necessary approvals.

No staff member will initiate corrective action without prior communication of findings through the proper channels.

12.2 Corrective Action During Data Validation and Data Assessment

The need for corrective action may be identified during data verification, data validation or data analysis. Potential types of corrective action may include resampling by the field team or reanalysis of data. These actions are dependent upon the ability to mobilize the field team and whether the data to be collected is necessary to meet the required QA objectives. If the Contractor QA Manager identifies a corrective action situation, the Contractor Project Manager will be responsible for informing the appropriate personnel. All corrective actions of this type will be documented by the Contractor Project Manager.

13.0 QUALITY ASSURANCE REPORTS

QA reports will be submitted to the Contractor Project Manager to ensure that any problems identified during the sampling and analysis programs are investigated and the proper corrective measures taken in response. The QA reports will include:

- All results of field audits,
- Problems noted during data verification, validation and assessment, and
- Significant QA/QC problems, recommended corrective actions, and the outcome of corrective actions.

QA reports will be prepared and submitted on an as-needed basis.

14.0 REFERENCES

Environmental Quality Board. 2010. Puerto Rico Water Quality Standards Regulation. Commonwealth of Puerto Rico, Office of the Governor. March 2010

United States Environmental Protection Agency. 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5. EPA/240/B-01/003. Reissue Notice May 2006.

United States Environmental Protection Agency. 2004. US EPA Region 2 Guidance for the Development of Quality Assurance Project Plants for Environmental Monitoring Projects. April 2004.

Washington Group. 2005. Puerto Rico Electric Power Authority, Santurce, Puerto Rico, Aguirre 316 Demonstration Study Type II Demonstration.

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE

DYE DILUTION STUDY
PREPA AGUIRRE POWER PLANT COMPLEX
CENTRAL AGUIRRE, PUERTO RICO

SOP NO. OSI-D-1

Prepared By: Ocean Surveys, Inc.
129 Mill Rock Rd. East
Old Saybrook, CT 06475

25 March 2011

TABLE OF CONTENTS

STANDARD OPERATING PROCEDURE

DYE DILUTION STUDY
PREPA AGUIRRE POWER PLANT COMPLEX
CENTRAL AGUIRRE, PUERTO RICO

SOP NO. OSI-D-1

1.0 SCOPE AND APPLICABILITY

This project Standard Operating Procedure (SOP) defines the procedures for measuring the transport and dilution of the PREPA Aguirre Power Plant Complex's discharge into the Bahia De Jobos through injection of Rhodamine WT fluorescent dye into the discharge at a controlled rate, monitoring the concentration of dye within the intake and discharge water, and mapping the horizontal and vertical distribution of the resultant dye plume using a specially equipped survey vessel and field team.

It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Quality Assurance (QA) Manager and the Remedial Investigation (RI) Task Manager. Deviations from this SOP will be documented in the field records. The ultimate procedure employed will be documented in the report summarizing the results of the sampling event or field activity.

2.0 HEALTH AND SAFETY CONSIDERATIONS

The health and safety considerations for the work associated with this SOP, including physical, chemical, and biological hazards are addressed in the site-specific Health and Safety Plan (HASP). The major health and safety considerations for the work associated with dye dilution collection are the marine safety aspects of the program.

Daily safety briefs are to be conducted at the start of each working day before any work commences. These daily briefs are to be facilitated by the Site Safety Officer (SSO) or his/her designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

3.0 INTERFERENCES

Ensuring that the fluorometers are maintained properly and calibrated will help reduce interference risks related to these data collection efforts.

Some quenching of the Rhodamine WT dye may occur due to any material or chemical present in the discharge flow. Field crews will conduct a "recovery test" to quantify any changes in dye concentration and apply those changes to the data during data processing. Recovery tests involve retrieving a sample from the discharge water and repeatedly measuring the fluorescence of the sample over time to detect any quenching (reduction) of the dye as a function of time.

4.0 EQUIPMENT AND MATERIALS

The following equipment list contains materials which may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity.

Additional equipment may be required, pending field conditions.

Injection Station:

- Field laptop computers
- Rhodamine WT dye

- Injection pump
- Scale
- 12V DC batteries
- Cleanup kit
- Safety gear (work vests, HASP specified personal protective equipment [PPE])

Sampling Stations (Intake and Discharge)

- Fluorometers
- Water pumps (DC bilge pumps)
- Field laptop computers
- 12V DC batteries

Sampling Vessel:

- Field log book
- Field laptop computers
- Fluorometers
- Water pumps (DC bilge pumps)
- Survey vessel fitted with differential global positioning system (DGPS) navigational equipment
- Safety gear (work vests, HASP specified personal protective equipment [PPE])

5.0 PROCEDURES

5.1 Calibration

All field fluorometers will be calibrated against dye dilution standards created from the specific manufacturer dye lot used for this study (OSI 1988). The range of the dilution standards will exceed both minimum and maximum values to be recorded in the field. Calibration curves will be established for each individual fluorometer and will be applied during post processing.

5.2 Dye Injection

Rhodamine WT, a fluorescent, water soluble, biodegradable tracer which can be accurately measured in extremely small concentrations shall be injected near the head of the plant's discharge.

Given a reported average daily flow of 652 MGD, Rhodamine WT will be injected at a rate sufficient to produce a discharge concentration of approximately 10 parts per billion (ppb). Assuming a discharge concentration of 10 ppb and a practical dye detection limit of 0.1 ppb above background, the field team will be able to accurately record the dye concentrations to a point where it has been diluted in excess of 100:1 (1%). The dye injection will be initiated 6-8 hours prior to plume mappings to ensure a sufficient plume has been generated within the discharge near-field zone.

5.3 Initial Concentration and Recirculation Monitoring

A fluorometer, fitted with a flow through sample chamber, will be used to monitor the *in situ* dye concentration of the plant's intake and discharge in real-time. The actual location of these measurements will be determined by the field crew after evaluation of the plant's configuration. At each location, a self-contained sampling station will be established. The initial concentration station will be placed at a point with sufficient distance from the dye injection station to allow complete mixing of the dye. The fluorometer and computer setup will record continuously throughout the study to document background conditions and dye injection concentrations.

5.4 Plume Mapping

The plume created from the discharge will be documented four times corresponding to high slack, maximum ebb, low slack and maximum flood tides. Each mapping will be completed over approximately a 2 hour time span every 6 hours over a twenty-four period to complement diurnal tidal conditions. The survey vessel will be equipped with a DGPS positioning system and fluorometer system. The plume will be mapped both horizontally and vertically along transects run perpendicular to the flow of the plume. Dye concentration will be collected continuously at a fixed depth of 1 foot along each transect with a line spacing that will gradually increase away from the diffuser. The plume will be mapped to a concentration of 1% or 3,000 feet from the diffuser, whichever comes first. This boundary is designed to focus the survey on the initial zone of dilution near the discharge. Vertical profiles will be completed periodically along the centerline of the plume. In addition, one transect and vertical profile will be completed prior to dye injection to document background conditions.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

It is the responsibility of the Field Task Manager (FTM) or designee to check the instrument calibration/test information, to spot check adherence to the procedural requirements of this SOP, and to review the associated documentation for accuracy and completeness. During boat-based transects or shore-based measurements, newly acquired data should be reviewed for reasonableness by the FTM or designee before moving off station.

7.0 DATA AND REPORTS MANAGEMENT

Field records will be generated and maintained to cover all aspects of collection including chronology of events, station locations, time/date, sampler name, and data collected.

During boat-based surveys *in situ* plume mapping data will be captured on a laptop PC using a data acquisition system that integrates the fluorometer instrumentation and navigation software.

Deviations to the procedures detailed in the SOP must be recorded in the field logbook at the time of occurrence, summarized on a non-conformance report, and communicated to the Project QA Manager no later than the end of the day.

8.0 PERSONNEL QUALIFICATIONS AND TRAINING

The individuals executing these procedures must have read, and be familiar with, the requirements of this SOP and the corresponding plans (e.g., HASP, QAPP, and FSP). Dye concentration data collection is a relatively simple procedure requiring minimal training. However, initial instrument calibration and sample/data collections should be supervised by the FTM or designee.

9.0 REFERENCES

OSI 1988; Ocean Surveys Inc. Dye Study Manual; June 1988.

10.0 REVISION HISTORY

Revision	Date	Changes
0	March 2011	NA

STANDARD OPERATING PROCEDURE

THERMAL PLUME STUDY
PREPA AGUIRRE POWER PLANT COMPLEX
CENTRAL AGUIRRE, PUERTO RICO

SOP NO. OSI-T-1

Prepared By: Ocean Surveys, Inc.
129 Mill Rock Rd. East
Old Saybrook, CT 06475

25 March 2011

TABLE OF CONTENTS

Page

STANDARD OPERATING PROCEDURE

THERMAL PLUME STUDY
PREPA AGUIRRE POWER PLANT COMPLEX
CENTRAL AGUIRRE, PUERTO RICO

SOP NO. OSI-D-1

1.0 SCOPE AND APPLICABILITY

This project Standard Operating Procedure (SOP) defines the procedures for measuring the thermal plume emanating from the PREPA Aguirre Power Plant Complex's discharge into the Bahia De Jobos. Thermal plume characteristics will be recorded through both temperature moorings and real-time boat-based transect surveys using a specially equipped survey vessel and field team.

It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Project Quality Assurance (QA) Manager and the Remedial Investigation (RI) Task Manager. Deviations from this SOP will be documented in the field records. The ultimate procedure employed will be documented in the report summarizing the results of the sampling event or field activity.

2.0 HEALTH AND SAFETY CONSIDERATIONS

The health and safety considerations for the work associated with this SOP, including physical, chemical, and biological hazards are addressed in the site-specific Health and Safety Plan (HASP). The major health and safety considerations for the work associated with dye dilution collection are the marine safety aspects of the program.

Daily safety briefs are to be conducted at the start of each working day before any work commences. These daily briefs are to be facilitated by the Site Safety Officer (SSO) or his/her designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

3.0 INTERFERENCES

Ensuring that the temperature probes and thermistors are maintained properly and calibrated will help reduce interference risks related to these data collection efforts.

Bio fouling is generally a concern related to mooring systems. However, bio fouling has a minimal influence on water temperature and the short duration of the mooring systems should eliminate any bio fouling concerns.

4.0 EQUIPMENT AND MATERIALS

The following equipment list contains materials which may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity.

Additional equipment may be required, pending field conditions.

Temperature Moorings:

- Onset Hobo Water Temperature Pro v2 data loggers
- Small surface buoys (1 foot in diameter)
- Mooring weights (20 lbs)
- Mooring line

Sampling Vessel:

- Field log book
- Field laptop computers
- Vessel-mounted YSI Model 44036 Series epoxy encapsulated thermistor probes
- Sea-Bird SBE-19 SeaCat Profiler
- Survey vessel fitted with differential global positioning system (DGPS) navigational equipment
- Safety gear (work vests, HASP specified personal protective equipment [PPE])

5.0 PROCEDURES

5.1 Calibration

All temperature probes and thermistors will be calibrated in a temperature bath prior to field operations. Each instrument will be subject to a variety of temperatures which will exceed both minimum and maximum values to be recorded in the field. Linear calibration curves will be established for each individual instrument and will be applied during post processing.

5.2 Temperature Moorings

All *in situ* temperature moorings will be deployed for a period of two days to encompass the real-time thermal mapping surveys. The instruments will all be set to record at 6-minute intervals to correspond to the NOAA tidal datasets. A proposed layout of the mooring locations is shown in Figure 1. A total of five (5) temperature moorings will be deployed in accordance with OSI's Instrument Mooring Handbook (OSI 1983). The moorings will be placed near the mouth of the discharge within the Bahia De Jobos. One mooring will be placed directly in front of the discharge while the remaining four moorings will be placed in a "T" formation at 500-foot spacing (Figure 1). Each mooring will consist of three Onset

Hobo Water Temperature Pro v2 data loggers positioned at 1 foot below the surface, mid depth, and 1 foot above the bottom.

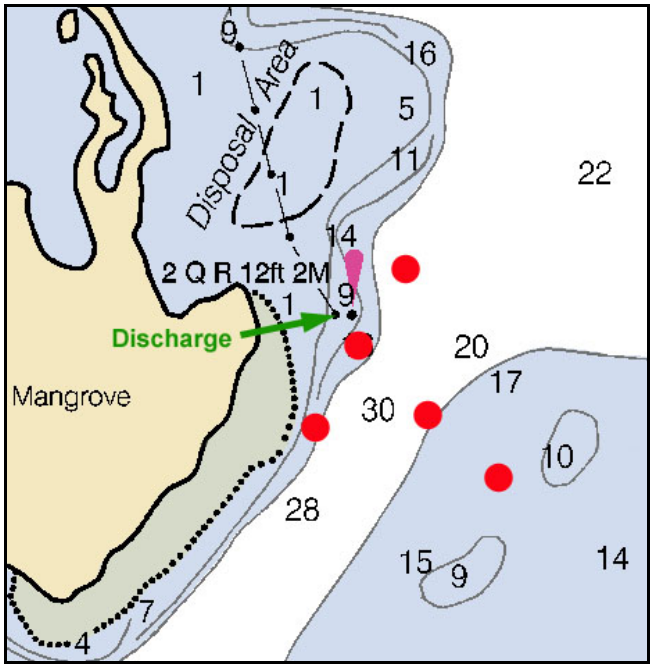


Figure 1. Temperature mooring layout.

In addition, field crews will attempt to deploy one temperature sensor near the head of the plant's discharge pipe to record initial conditions. However, due to a lack of knowledge of the discharge structure configuration this may not be possible.

5.3 Thermal Plume Mapping

The thermal mapping program will be implemented over one complete tidal cycle. The purpose of this mapping program is to document the horizontal and vertical temperature plumes emanating from the existing power station. The field crew will conduct four mappings coinciding with maximum flood, high slack, maximum ebb and low stack tidal periods. Each mapping will be completed over approximately a 2 hour time span every 6 hours over a twenty-four hour period to complement diurnal tidal conditions.

Temperature data will be collected along a series of transects across the existing plume structure. The horizontal temperature distribution will be acquired using a thermal monitoring system interfaced to a DGPS navigational software system aboard the survey vessel. The thermal monitoring system will consist of a central processing unit with hard wire thermistor inputs. Thermistors will be constructed of YSI Model 44036 Series epoxy encapsulated thermistor probes with a temperature range of -112ºF to 167ºF and an accuracy of ±-0.1ºF for the full range.

For this project, a bundled set of two thermistors will be used for backup and redundancy. These probes will be located on the side of the survey vessel, directly under the DGPS antenna, at a depth of 1.0 foot below the surface of the water. Data from the probes will be uploaded at 2 Hz into the navigational computer system and combined with the x and y positioning data. The horizontal mapping operations will be completed over a minimum of 10 lines (typically 10-15 lines) in approximately 2 hours.

The vertical temperature and density structure of the water column will be documented throughout each mapping using a Sea-Bird SBE-19 SeaCat Profiler for vertical temperature and conductivity measurements. The SeaCat profiler is a self-powered, self-contained micro processing unit capable of collecting temperature, conductivity and depth data at a rate of two scans per second. Profiles will be collected at selected sites along the approximate centerline of the plume.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

It is the responsibility of the Field Task Manager (FTM) or designee to check the instrument calibration/test information, to spot check adherence to the procedural requirements of this SOP, and to review the associated documentation for accuracy and completeness. During boat-based transects or mooring measurements, newly acquired data should be reviewed for reasonableness by the FTM or designee before moving off station.

7.0 DATA AND REPORTS MANAGEMENT

Field records will be generated and maintained to cover all aspects of collection including chronology of events, station locations, time/date, sampler name, and data collected.

During boat-based surveys *in situ* thermal plume mapping data will be captured on a laptop PC using a data acquisition system that integrates the thermistor instrumentation and navigation software.

Deviations to the procedures detailed in the SOP must be recorded in the field logbook at the time of occurrence, summarized on a non-conformance report, and communicated to the Project QA Manager no later than the end of the day.

8.0 PERSONNEL QUALIFICATIONS AND TRAINING

The individuals executing these procedures must have read, and be familiar with, the requirements of this SOP and the corresponding plans (e.g., HASP, QAPP, DMP, and FSP). Temperature data collection is a relatively simple procedure requiring minimal training. However, initial instrument calibration and sample/data collections should be supervised by the FTM or designee.

9.0 REFERENCES

OSI 1983; Ocean Surveys Inc. Instrument Mooring Handbook; Rev. 0, September 16, 1983.

10.0 REVISION HISTORY

Revision	Date	Changes
0	March 2011	NA

Appendix C

Correspondence

GOBIERNO DE PUERTO RICO
AUTORIDAD DE ENERGÍA ELÉCTRICA DE PUERTO RICO

SAN JUAN, PUERTO RICO

www.aeepr.com

APARTADO 364267
CORREO GENERAL
SAN JUAN, PR 00936-4267

23 de noviembre de 2011

CORREO CERTIFICADO 7010 2780 0002 7649 4717

Sra. Annette Feliberty Ruiz, Jefa División
Permisos de Fuentes Precisadas
Junta de Calidad Ambiental
PO Box 11488
San Juan, P R 00910

Estimada señora Feliberty Ruíz:

El 20 de septiembre recibimos la aprobación de la Junta de Calidad Ambiental (JCA), de los documentos:

- Plan de Trabajo para la Confiabilidad de Calidad del Estudio de Tinte o en su lugar un Estudio Termal
- Plan de Trabajo para la Confiabilidad de Calidad del Monitoreo de Temperatura

La aprobación fue condicionada al cumplimiento de varios requisitos entre los que se encuentra "Ambos estudios (estudios termal y muestreo de zona de mezcla) deberán ser realizados durante la operación continua del Complejo Generatriz de Aguirre para garantizar la representatividad de las muestras".

Según la Condición Especial 23.n del Permiso NPDES para el Complejo, estos trabajos deben comenzar no más tarde de 90 días de aprobados por escrito lo que ubica la fecha de comienzo previo al 19 de diciembre (si tomamos como base el recibo de la carta) o el 8 de diciembre (si tomamos como base la fecha de la carta).

No obstante, la Unidad 1 del Complejo Generatriz se encuentra en reparación desde octubre de 2011. Se estima que retornará a servicio continuo para el 8 de enero de 2012 y el 12 de enero de 2012 saldrá de servicio la Unidad 2. Esto provee una ventana del 8 al 12 de enero de 2012 para el primer evento de muestreo de la zona de mezcla y simultáneamente, el primer estudio termal. Esta fecha excede los 90 días establecidos para el comienzo de los trabajos, pero satisface la condición de operación representativa de las unidades. De no poder realizar el primer evento de ambos estudios durante la fecha indicada, será necesario esperar hasta el retorno de la Unidad 2 a servicio continuo en marzo de 2012 para dicho evento.

Por otro lado, la condición 3 de la carta de aprobación indica que "Como parte del estudio termal del penacho de la descarga de la instalación se van a desplegar cinco amarraderos con el equipo necesario para el registro de los datos de temperatura y conductividad". Aclaramos que los amarraderos consisten de tres termistores instalados a tres profundidades diferentes para evaluar la disipación del penacho termal a lo largo de una línea. Además de éstos, se desplegará equipo 4 veces durante las 24 horas del ciclo de la marea, para obtener el perfil de temperatura vertical y densidad de la columna de agua en aproximadamente 6 localizaciones diferentes, que no necesariamente coincidirán con los amarraderos. Según se indica en la condición establecida, las localizaciones de los amarraderos y del despliegue de los equipos adicionales serán documentadas con mapas y coordenadas en el informe final.

De necesitar más información, puede comunicarse con el Sr. Ruperto Berríos Santos, Gerente del Departamento de Calidad de Agua, por el 787-521-4965.

Cordialmente,

Javier Morales Tañón, Jefe Interino
División de Protección Ambiental
y Confiabilidad de Calidad

Anejos

PA-6633

23 de noviembre de 2011

CORREO CERTIFICADO 7010 2780 0002 7649 4717

Sra. Annette Feliberty Ruiz, Jefa División
Permisos de Fuentes Precisadas
Junta de Calidad Ambiental
PO Box 11488
San Juan, P R 00910

Estimada señora Feliberty Ruíz:

El 20 de septiembre recibimos la aprobación de la Junta de Calidad Ambiental (JCA), de los documentos:

- Plan de Trabajo para la Confiabilidad de Calidad del Estudio de Tinte o en su lugar un Estudio Termal
- Plan de Trabajo para la Confiabilidad de Calidad del Monitoreo de Temperatura

La aprobación fue condicionada al cumplimiento de varios requisitos entre los que se encuentra "Ambos estudios (estudios termal y muestreo de zona de mezcla) deberán ser realizados durante la operación continua del Complejo Generatriz de Aguirre para garantizar la representatividad de las muestras".

Según la Condición Especial 23.n del Permiso NPDES para el Complejo, estos trabajos deben comenzar no más tarde de 90 días de aprobados por escrito lo que ubica la fecha de comienzo previo al 19 de diciembre (si tomamos como base el recibo de la carta) o el 8 de diciembre (si tomamos como base la fecha de la carta).

No obstante, la Unidad 1 del Complejo generatriz se encuentra en reparación desde octubre de 2011. Se estima que retornará a servicio continuo para el 8 de enero de 2012 y el 12 de enero de 2012 saldrá de servicio la Unidad 2. Esto provee una ventana del 8 al 12 de enero de 2012 para el primer evento de muestreo de la zona de mezcla y simultáneamente, el primer estudio termal. Esta fecha excede los 90 días establecidos para el comienzo de los trabajos, pero satisface la condición de operación representativa de las unidades. De no poder realizar el primer evento de ambos estudios durante la fecha indicada, será necesario esperar hasta el retorno de la Unidad 2 a servicio continuo en marzo de 2012 para dicho evento.

Por otro lado, la condición 3 de la carta de aprobación indica que "Como parte del estudio termal del penacho de la descarga de la instalación se van a desplegar cinco amarraderos con el equipo necesario para el registro de los datos de temperatura y conductividad". Aclaramos que los amarraderos consisten de tres termistores instalados a tres profundidades diferentes para evaluar la disipación del penacho termal a lo largo de una línea. Además de éstos, se desplegará equipo 4 veces durante las 24 horas del ciclo de la marea, para obtener el perfil de temperatura vertical y densidad de la columna de agua en aproximadamente 6 localizaciones diferentes, que no necesariamente coincidirán con los amarraderos. Según se indica en la condición establecida, las localizaciones de los amarraderos y del despliegue de los equipos adicionales serán documentadas con mapas y coordenadas en el informe final.

De necesitar más información, puede comunicarse con el Sr. Ruperto Berríos Santos, Gerente del Departamento de Calidad de Agua, por el 787-521-4965.

Cordialmente,

Javier Morales Tañón, Jefe Interino
División de Protección Ambiental
y Confiabilidad de Calidad

Anejos

RBS/JAP/MCS/mch

K:\Permisos\Aguirre\Protocolo\aclaración fecha comienzo estudios.docx

JAIME A. PLAZA

From: Wilson, Stephanie K. <stephanie.wilson@aecom.com>
Sent: Wednesday, October 05, 2011 9:11 AM
To: JAIME A. PLAZA
Subject: RE: AGUIRRE THERMAL STUDY

Hello Jaime

I had prepared an email yesterday and was waiting for confirmation from OSI regarding some of the details. In the EQB letter, item #3 states that "as part of the thermal plume study, five moorings will be deployed with the necessary equipment to record temperature and conductivity data." What we intend to do and the QAPP states that in-situ temperature moorings will be deployed near the mouth of the discharge. Each mooring will consist of three thermistors placed at one foot below the surface, mid-depth and one foot above the bottom. These moorings are located to evaluate the dissipation of the plume along a line. In addition, the vertical temperature and density structure of the water column will be documented during the plume study by deploying a water quality profiler instrument as select locations throughout the tidal cycle to collect temperature and conductivity measurements. The water quality profiler will not be moored, instead it will be deployed 4 times during the 24 hour tidal cycle, at select locations (approx. 6), depending on the size and extent of the plume. We don't anticipate these locations coinciding exactly with the mooring locations because we want to evaluate the full extent of the plume, not just along a line. In all cases, we will provide maps and coordinates of the deployment locations in the final reports.

Please let me know if this is clear. Thanks

Stephanie

Stephanie J. K. Wilson
Senior Project Manager/ Marine Scientist
Environment
D 978.905.2461
stephanie.wilson@aecom.com

AECOM
250 Apollo Drive
Chelmsford, MA 01824.
T 978.905.2100
www.aecom.com

Please note that as of July 1, 2011, the AECOM Westford office has moved to Chelmsford.

GOBIERNO DE PUERTO RICO
OFICINA DEL GOBERNADOR
JUNTA DE CALIDAD AMBIENTAL

PUERTO RICO VERDE

Área de Calidad de Agua

CERTIFICADA CON ACUSE DE RECIBO

9 de septiembre de 2011

11 SEP 20 PM 3:54

Ing. Jaime A. Plaza
Jefe
División Protección Ambiental y Confiabilidad de Calidad
Autoridad de Energía Eléctrica de Puerto Rico
P.O. Box 364267
San Juan, Puerto Rico 00936-4267

Estimado ingeniero Plaza:

RE: ***QUALITY ASSURANCE PROJECT PLAN DYE DILUTION STUDY AND MIXING ZONE MONITORING PROTOCOL QUALITY ASSURANCE PROJECT PLAN***
AGUIIRRE POWER PLANT COMPLEX
SALINAS, PUERTO RICO
NPDES No. PR0001660

Los documentos en epígrafe fueron sometidos al Área de Calidad de Agua (ACA) de la Junta de Calidad Ambiental (JCA) por la Autoridad de Energía Eléctrica de Puerto Rico (AEE), para nuestra evaluación y aprobación. Los mismos fueron sometidos el 4 de abril de 2011, para cumplir con lo requerido en el permiso NPDES vigente de la instalación antes mencionada.

En el documento, *Quality Assurance Project Plan Dye Dilution Study* (QAPPDS) la AEE presenta, además del estudio de tinte requerido por el permiso NPDES, la alternativa de llevar a cabo un estudio termal del penacho de la descarga del Complejo Generatriz Aguirre. La AEE solicita que se apruebe el estudio termal ya que el mismo proveerá los datos necesarios para validar el modelo matemático usado para definir la zona de mezcla interina para la descarga de la instalación antes mencionada, de una forma más directa y efectiva que con el estudio de tinte.

Luego de la evaluación correspondiente, el ACA determinó aprobar de forma condicionada el estudio termal presentado en el QAPPDS y el *Mixing Zone Monitoring Protocol Quality Assurance Project Plan*, siempre y cuando la AEE cumpla con lo siguiente:

1. Ambos estudios (estudio termal y muestreo de zona de mezcla) deberán ser realizados durante la operación continua del Complejo Generatriz Aguirre para garantizar la representatividad de las muestras.

2. En el documento, *Mixing Zone Monitoring Protocol Quality Assurance Project Plan* se indica que personal de la AEE identificó los puntos donde se ubicarán las estaciones de muestreo en los bordes de la zona de mezcla, sin embargo no se incluyó la tolerancia máxima en comparación con las coordenadas originales establecidas para la zona de mezcla interina. Por lo que, deberán incluir esta información como parte del informe final.

3. Como parte del estudio termal del penacho de la descarga de la instalación se van a desplegar cinco amarraderos con el equipo necesario para el registro de datos de temperatura y conductividad. Un amarradero será ubicado directamente en frente de la descarga mientras que los otros cuatro serán ubicados en forma de "T" a una distancia de 500 pies. Sin embargo, no se incluyeron las coordenadas de los puntos donde estos amarraderos van a estar ubicados, por lo que deberán incluir las coordenadas antes mencionadas como parte del informe final.

4. Antes de comenzar el estudio, el peticionario deberá notificar a las distintas agencias federales y estatales tales como:

   a. Agencia Federal para la Protección Ambiental (EPA, por sus siglas en ingles).
   b. Guardia Costanera de los Estados Unidos (USCG)
   c. National Oceanic and Atmospheric Administration (NOAA)
   d. Junta de Calidad Ambiental (JCA)
   e. Autoridad de los Puertos
   f. Departamento de Recursos Naturales y Ambientales (DRNA)

Una vez se realicen los estudios antes mencionados en cumplimiento con lo señalado en esta carta, la AEE deberá someter un informe de los resultados obtenidos al ACA de la JCA para su evaluación. La aprobación condicionada de este documento no releva a esta Junta de requerir información adicional en caso de ser necesario. Además, cualquier cambio o modificación que requiera este documento deberá someterse por escrito al ACA para su evaluación y aprobación previo a su realización.

Ing. Jaime A. Plaza
Quality Assurance Project Plan Dye Dilution Study and Mixing Zone Monitoring Protocol Quality Assurance Project Plan
Aguirre Power Plant Complex
Página 3

De tener alguna duda o pregunta en torno a este particular, estamos en la mejor disposición de ofrecerle toda la orientación que esté a nuestro alcance. De ser este el caso puede comunicarse con la Sra. Luz Dary Sánchez Tosado de la División de Permisos para Fuentes Precisadas al teléfono (787) 767-8181, extensión 3456, a su mejor conveniencia.

Cordialmente,

Roberto Ayala Prado
Director
Area de Calidad de Agua

LDS/dcc

G:\División Permisos Fuentes Precisadas\División Permisos Fuentes Precisadas\WORD\Luz Dary\NPDES\otros\Aprobación Condicionada QAPP ZM y Estudio de Tinte Aguirre NPDES PR0001660.doc

Special Condition 23

Alternatively, if no samples are taken during the month, the permittee will be considered to have met its sampling requirement if the permittee certifies that it was not possible to meet the specified sampling protocol during the first fifteen (15) days of the month and that there was no appreciable discharge of storm water during normal business hours from the sixteenth (16^{th}) day of the month to the last day of the month.

18. The storm water discharges associated with industrial activities covered by this WQC will not cause violations to the applicable water quality standards at the receiving water body. [3]

19. The flow measuring devices for the discharges 002, 003 and 004 shall be periodically calibrated and properly maintained. Calibration and maintenance records must be kept in compliance with the applicable Rules and Regulations. [4,6]

20. The sampling points for discharges 001, 002, 003, 004 and 005 shall be located immediately after the primary flow measuring devices of the effluents.

21. The sampling points for discharges 001, 002, 003, 004 and 005 shall be labeled with a 18 inches x 12 inches (minimum dimensions) sign that reads as follows:

"PUNTO DE MUESTREO PARA LA DESCARGA 001"
"PUNTO DE MUESTREO PARA LA DESCARGA 002"
"PUNTO DE MUESTREO PARA LA DESCARGA 003"
"PUNTO DE MUESTREO PARA LA DESCARGA 004"
"PUNTO DE MUESTREO PARA LA DESCARGA 005"

22. All water or wastewater treatment facility, whether publicly or privately owned, must be operated by a person licensed by the Potable Water and Wastewaters Treatment Plants Operators Examining Board of the Commonwealth of Puerto Rico. [4]

23. The EQB has defined and authorized an Interim Mixing Zone (IMZ) pursuant to Article 5 of the Puerto Rico Water Quality Standards Regulation (PRWQSR), as amended. [3]

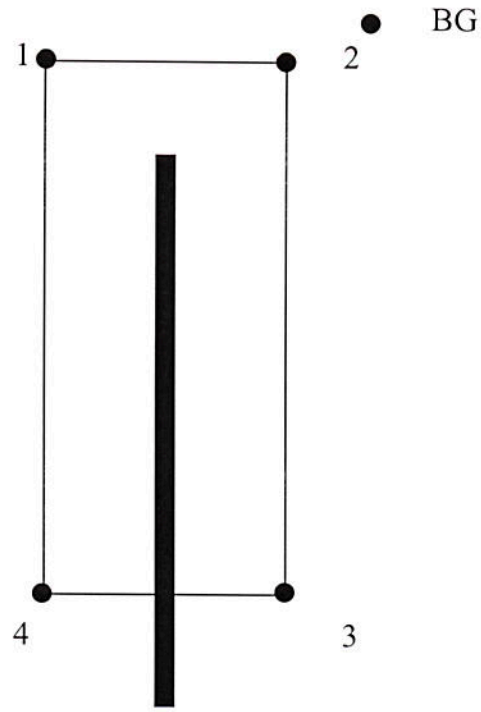
    a. The IMZ is delineated by the following points (See Diagram I):

    b. The interim mixing zone sampling stations shall be located at the four (4) points described in Part "a" of this special condition.

    c. The background sampling station shall be located one hundred (100) meters from Point 3 or Point 4 of the mixing zone, depending of the current direction at the time of sampling. The petitioner shall determine and submit to EQB the geographic coordinates of both background stations.

Special Condition 25

DIAGRAM-I
Aguirre Power Complex Mixing Zone



Geographic Coordinates

Point 1	Lat. 17º 55' 53.18" Long. 66º 13' 28.04"
Point 2	Lat. 17º 55' 49.08" Long. 66º 13' 43.77"
Point 3	Lat. 17º 56' 19.21" Long. 66º 13' 52.34"
Point 4	Lat. 17º 56' 23.31" Long. 66º 13' 36.60"

The submerged outfall has a length of five thousand eight hundred (5,800) feet long and a diameter of thirteen (13) feet. The diffuser has one port at the end that is a ten (10) feet restrictor.

Special Condition 2:

d. The permittee shall maintain records of the equipment used to situate at the mixing zone boundaries. Such records shall include the date when the equipment was obtained or leased, calibration date, serial number, model, etc.

To identify the location of the sampling points of the mixing zone and the background, the permittee shall use the procedure established in the EPA-QA/QC for 301(h) Cocument (Table D-1 Example ZID Boundary Stations Locations).

If the permittee determines to use another method to identify the sampling points of the mixing zone, the permittee shall, prior to the utilization of such method, obtain written approval from EQB.

e. The IMZ is defined for the following parameter:

Parameter	**Daily Maximum DischargeLimitation at Outfall Serial Number 001**	**Daily Maximum Limitation at the Edge of the IMZ**
Temperature (°C)	41.1	32.2

f. Monitoring samples for this parameter shall be taken at the sampling point 001, the background monitoring station and at the sampling points of the IMZ. The discharge shall comply with the water quality standards at sampling point 001, for all the other substances.

g. The monitoring samples at the four (4) stations in the boundaries of the IMZ and the background monitoring station shall be taken at three (3) depths in each station: 10%, 50%, 90% of the depth.

h. Solids from wasterwater sources shall not cause deposition in, or be deleterious to the existing or designated uses of the waters.

i. The discharge shall not cause the growth or propagation of organisms that negatively disturb the ecological equilibrium in the areas adjacent to the mixing zone.

j. The mixing zone shall be free of debris, scum, floating oil and any other substance that produce objectionable odors.

k. The permittee shall maintain in good operating conditions the discharge system [discharge outfall (land and submarine), diffuser, ports, etc.]. At least once a year, the discharge system shall be inspected to determine if some repairs, replacing, etc., on the discharge system is required. A report of such inspections shall be submitted to EPA and EQB not later than sixty (60) days after the performance of the inspection.

l. The EQB can require that the permittee conduct bioaccumulation studies, dye studies, water quality studies or any other pertinent studies. If the EQB require one or more of the aforementioned studies, the permittee will be notified to conduct such study(ies). One hundred and twenty (120) days after the notification of the EQB, the permittee shall submit, for evaluation and approval of the

EQB, a protocol to conduct such study(ies). Sixty (60) days after the EQB approval, the permittee shall initiate such study(ies). Ninety (90) days after conducting such study(ies), the permittee shall submit a report that includes the results of such study(ies).

m. The permittee shall implement a one year monitoring program to obtain the necessary data to validate the IMZ. The monitoring program shall consist of the sampling of the parameters included in Part "e" of this special condition to verify compliance with the applicable provisions of the PRWQSR and a dye study to validate the mathematical model used to determine the critical initial dilution and verify the behavior of the plume within the mixing zone. The monitoring program shall be conducted as follows:

1. The permitte shall conduct four (4) sampling events at the four (4) stations at the boundaries of the IMZ, at the background sampling station and at the sampling point of discharge 001, during two seasons (summer and winter). Two sampling events shall be conducted during each season.

2. The dye study shall be conducted twice, one event during each season, the same time as one of the sampling events of the season.

n. The monitoring program shall comence ninety (90) days after the written approval of the corresponding Protocol and Quality Assurance Project Plan (QAPP). Such Protocol and QAPP shall be submitted to EQB by March 31, 2011.

o. If the mathematical model is validated as established in the applicable provisions of the PRWQSR and in the Mixing Zone and Bioassays Guidelines, a final mixing zone authorization will be issued by EQB. Nevertheless, if the mathematical model is not validated, the EQB may revoke the IMZ authorization in accordance with Article 5.14 of the PRWQSR. In such case, the permittee must submit a compliance plan according to Article 5.16 of the PRWQSR.

p. The EQB can allow that the permittee use alternative methods for the mixing zone validation if such methods comply with the applicable federal and state regulations or when new technology is developed that produce results technically and environmentally more reliable than those produced by the methods described in this special condition.

q. The EQB will determine if the effluent limitations will be final or if it is necessary to reopen the WQC to modify (increase or decrease) the effluent limitation for the aforementioned parameter after the revision of the results obtained in the studies required in this special condition.

r. The authorization for the mixing zone will not be transferable and does not convey any property rights of any sort or any exclusive privileges, nor does it authorize any injury to persons or property or invasion of other private rights, or any infringement of Federal or State laws or regulations.

24. The permittee shall conduct semiannual definitive acute and chronic toxicity tests using the organisms *Mysidopsis bahia*, *Cyprinodon variegatus* and *Arbacia punctulata* for the wastewater discharges identified as 001, 002, 003 and 004.